Residential Energy Code Update

REScheck and Beyond

Montana 2016

March 2016
Dale Horton Architect
National Center for Appropriate Technology

NorthWestern Energy
Northwest Energy Efficiency Alliance

Presentation Outline

- Overview of residential energy code
- Energy Code Challenges
- REScheck Compliance Software
- Beyond code

Presentations Online

http://www.ncat.org

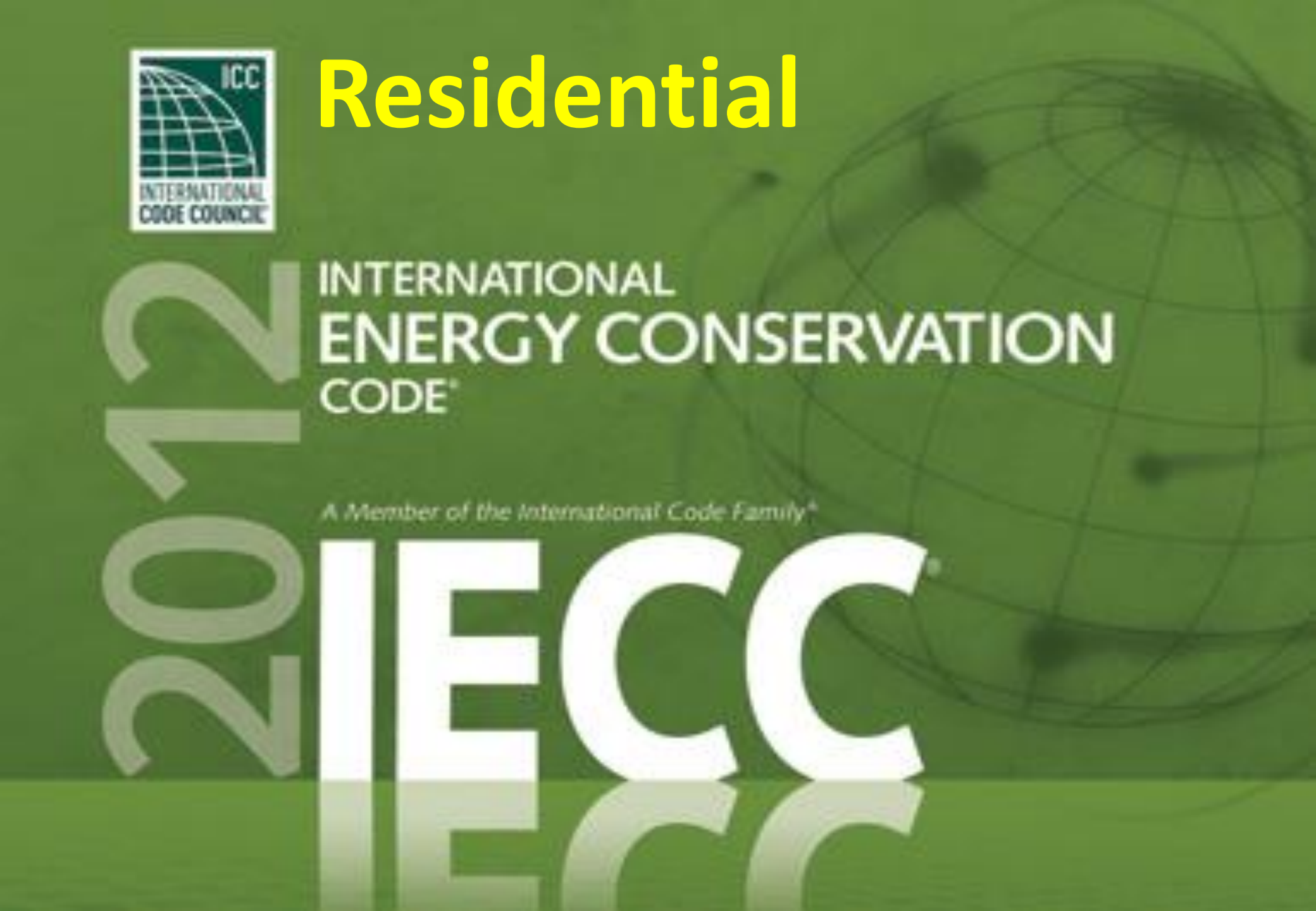
➔Energy

➔Energy Code
Training Presentations

Do energy codes drive technology?

Or

Does technology drive energy codes?


Residential
2012
INTERNATIONAL
ENERGY CONSERVATION
CODE
A Member of the International Code Family
IECC

Montana Energy Code vs. 2012 IECC

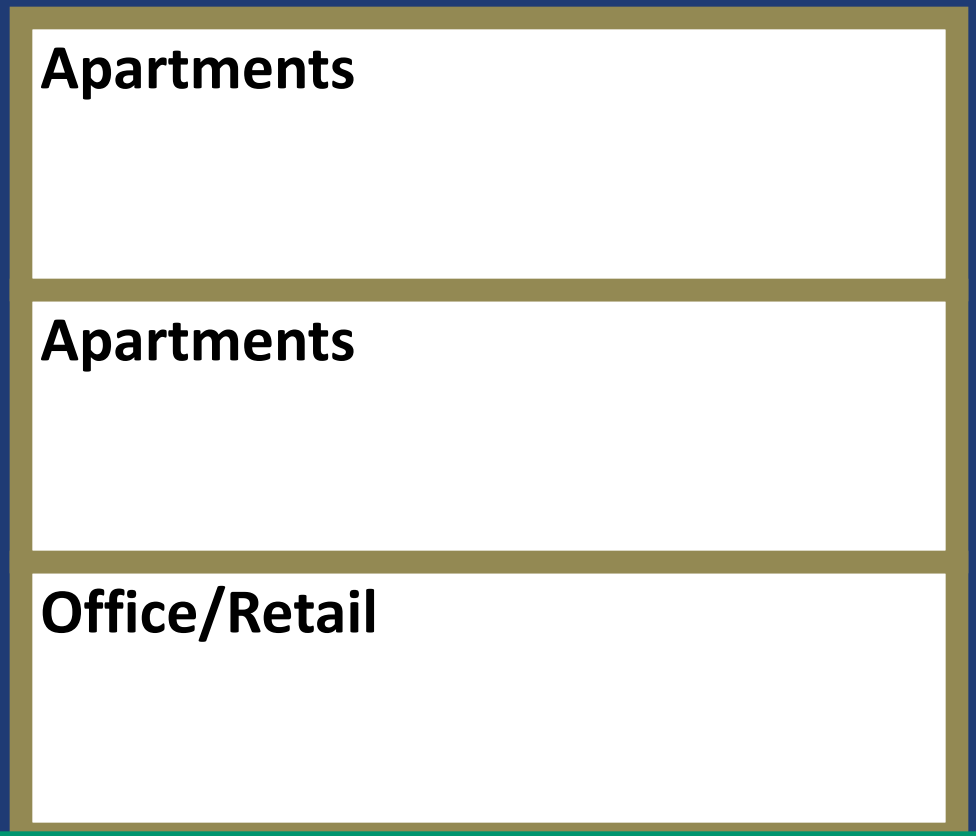
- Frame wall insulation requirement unchanged (2012 IECC requires added R5 insulation sheathing)
- Maximum house air tightness unchanged at 4 ACH50 (2012 IECC is 3 ACH50)
- Duct leakage to outside test allowed
- May use building cavities as return ducts in Montana but not in the 2012 IECC
- Most DHW distribution pipe insulation requirements of 2012 IECC not adopted in Montana

Definitions

Residential Building

- Detached one and two family dwellings
- Multiple single family dwellings and townhouses
- Group R-2, R-3, R-4 <= 3 stories in height

Does Residential or Commercial Apply?



In this 3-story mixed occupancy building would the commercial or residential sections apply to each floor?

Does Residential or Commercial Apply?

In this 4-story mixed occupancy building would the commercial or residential sections apply to each floor?

Additions, Alterations, Renovations, and Repairs

R101.4.3

Additions - Treat as a stand-alone building or with whole building.

Alterations, Renovations, & Repairs where permit is required. Note the exceptions!

R401.2

Mandatory Provisions

+

Prescriptive

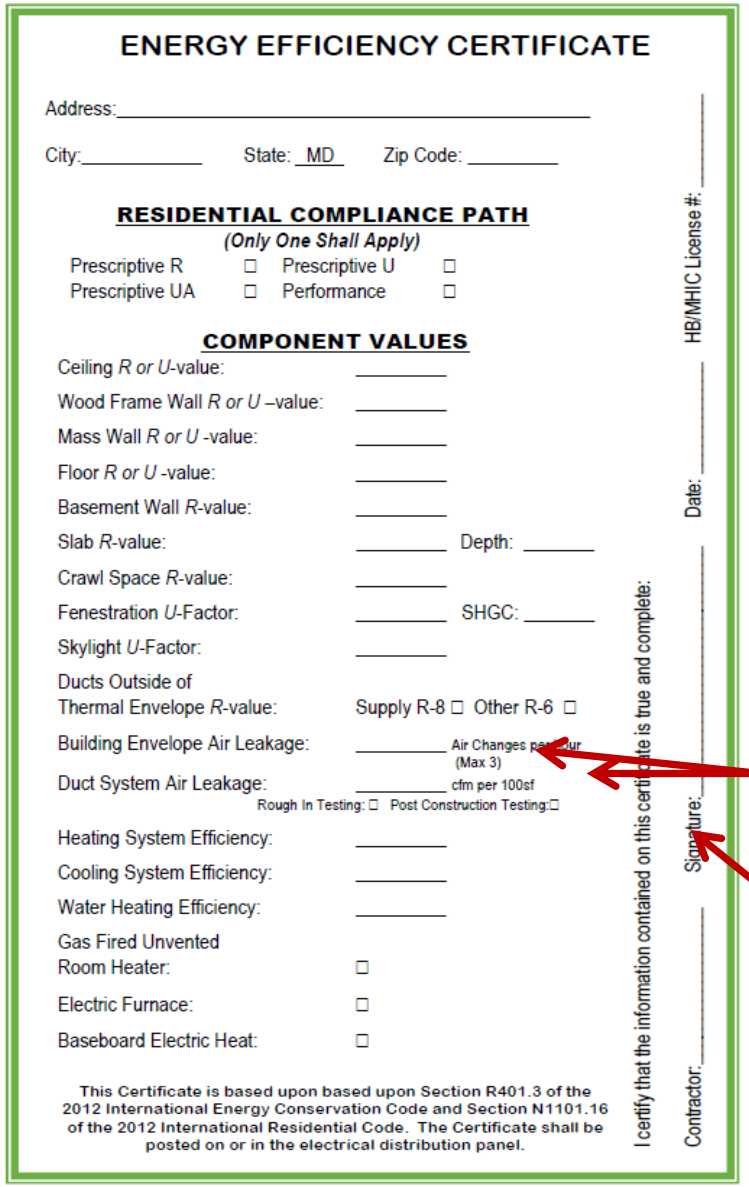
- R-Value
- U-Factor Alternative
- UA Alternative

OR

Performance

Certificate (Mandatory)

R401.3



ENERGY EFFICIENCY CERTIFICATE

Address:_____

City:_____ State: MD Zip Code: _____

RESIDENTIAL COMPLIANCE PATH

(Only One Shall Apply)

Prescriptive R ☐ Prescriptive U ☐

Prescriptive UA ☐ Performance ☐

COMPONENT VALUES

Ceiling *R or U*-value: _____

Wood Frame Wall *R or U* –value: _____

Mass Wall *R or U* -value: _____

Floor *R or U* -value: _____

Basement Wall *R*-value: _____

Slab *R*-value: _____ Depth: _____

Crawl Space *R*-value: _____

Fenestration *U*-Factor: _____ SHGC: _____

Skylight *U*-Factor: _____

Ducts Outside of Thermal Envelope *R*-value: Supply R-8 ☐ Other R-6 ☐

Building Envelope Air Leakage: _____ Air Changes per Hour (Max 3)

Duct System Air Leakage: _____ cfm per 100sf

Rough In Testing: ☐ Post Construction Testing:☐

Heating System Efficiency: _____

Cooling System Efficiency: _____

Water Heating Efficiency: _____

Gas Fired Unvented Room Heater: ☐

Electric Furnace: ☐

Baseboard Electric Heat: ☐

This Certificate is based upon based upon Section R401.3 of the 2012 International Energy Conservation Code and Section N1101.16 of the 2012 International Residential Code. The Certificate shall be posted on or in the electrical distribution panel.

I certify that the information contained on this certificate is true and complete:

HB/MHIC License #: _____

Date: _____

Signature: _____

Contractor: _____

Place on electrical panel.

- R-Values
- U-Factors & SHGC
- Envelope Air Leakage
- Space Conditioning Efficiencies
- Duct Tightness Test
- Building Tightness Test
- Duct R-Values
- Builder Signature

Not All R-Values Are Created Equal

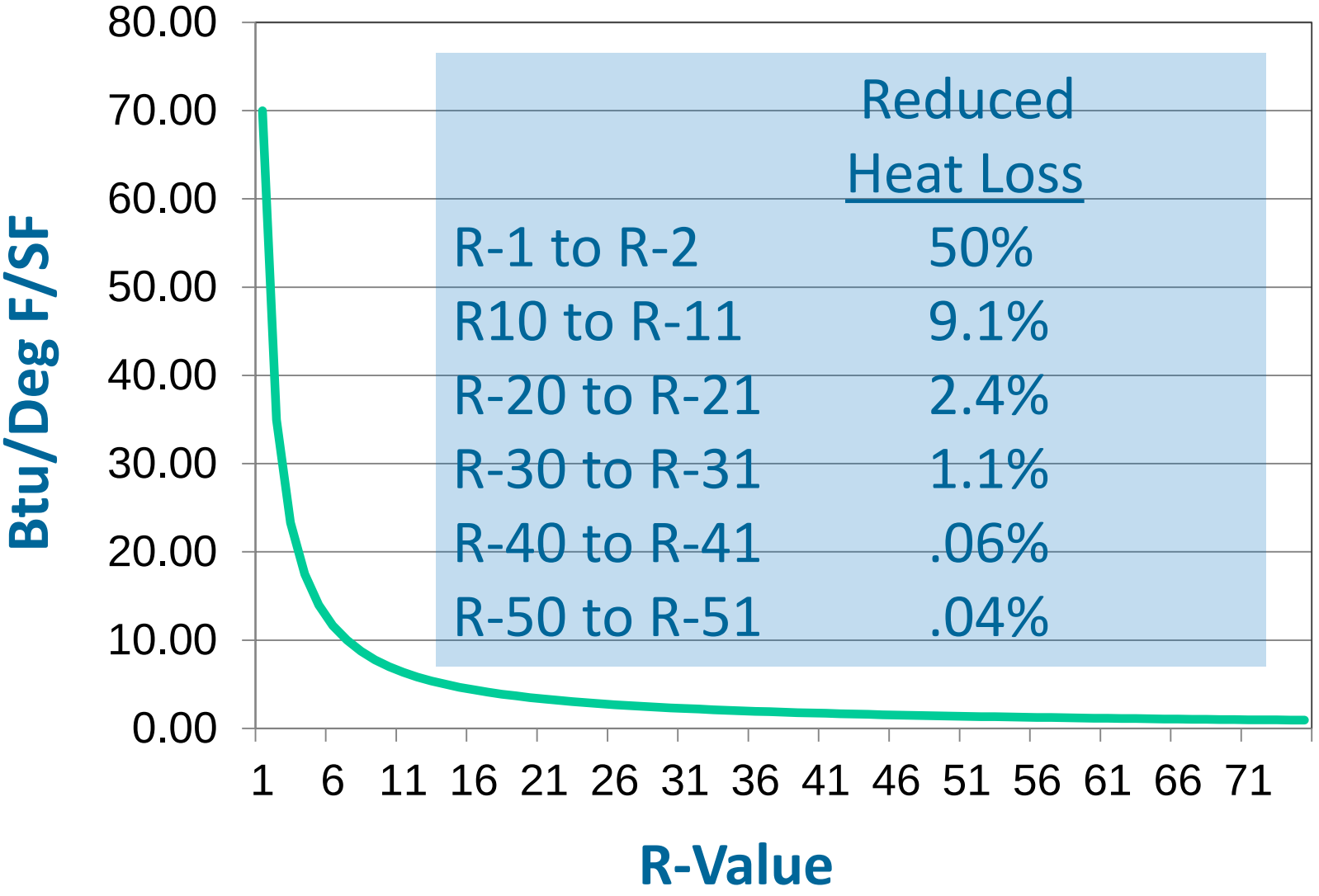


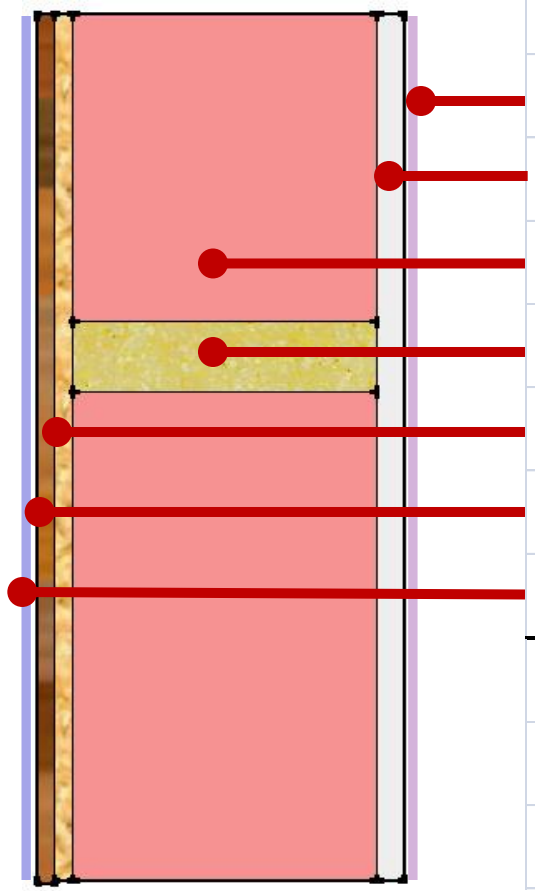
TABLE R402.1.1 (Amended)										
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT										
CLIMATE ZONE	FENESTRATION *U*- FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.4	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	13	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.4	49	20 or 13+5[h]	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	21 or 13+5[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.32	0.55	NR	49	20+5 or 13+10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

R402.1.1
Table of R-Values and U-Factors

Table R402.1.3								
EQUIVALENT U-FACTORS								
CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRAWL SPACE WALL U-FACTOR
1	0.50	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.082	0.165	0.064	0.360	0.477
3	0.35	0.55	0.030	0.057	0.098	0.047	0.091	0.136
4 except Marine	0.35	0.55	0.026	0.057	0.098	0.047	0.059	0.065
5 & Marine 4	0.32	0.55	0.026	0.057	0.082	0.033	0.050	0.055
6	0.32	0.55	0.026	~~0.048~~ **0.054**	0.060	0.033	0.050	0.055
7 and 8	0.32	0.55	0.026	0.048	0.057	0.028	0.050	0.055

R402.1.3
Table of U-Factors

Calculating Assembly U-Factors



	R-Value Cavity		R-Value Framing
Inside air film	0.68		0.68
Gypsum board	0.45		0.45
Cavity insulation	21.00		-------
5.5” Stud	-------		6.80
Exterior sheathing	0.50		0.50
Exterior siding	1.00		1.00
Outside Air Film	0.17		0.17
Total R-value	23.80		9.60
U-Value	0.042		0.104
Area Fraction	0.80		0.20

Area Weighted U-Factor = $(Area1_{Frac} \times U1) + (Area2_{Frac} + Area2)$

Area Weighted U-Factor = (0.8 x 0.042) + (0.2 x 0.104) = 0.054

Area Weighted R-Value = (1/.054) = 18.38

Compliance Paths

R402.1.4

Compliance Paths

Mandatory + Prescriptive
R-Value Computation

Mandatory + Prescriptive
U-Factor Alternative

Mandatory + Prescriptive
Total UA Alternative

Mandatory + Performance
Simulated Performance Alternative

TABLE R402.1.3
EQUIVALENT *U*-FACTORS[a]

CLIMATE ZONE	FENESTRATION *U*-FACTOR	SKYLIGHT *U*-FACTOR	CEILING *U*-FACTOR	FRAME WALL *U*-FACTOR	MASS WALL *U*-FACTOR[b]	FLOOR *U*-FACTOR	BASEMENT WALL *U*-FACTOR	CRAWL SPACE WALL *U*-FACTOR
1	0.50	0.75	0.035	0.082	0.197	0.064	0.360	0.477
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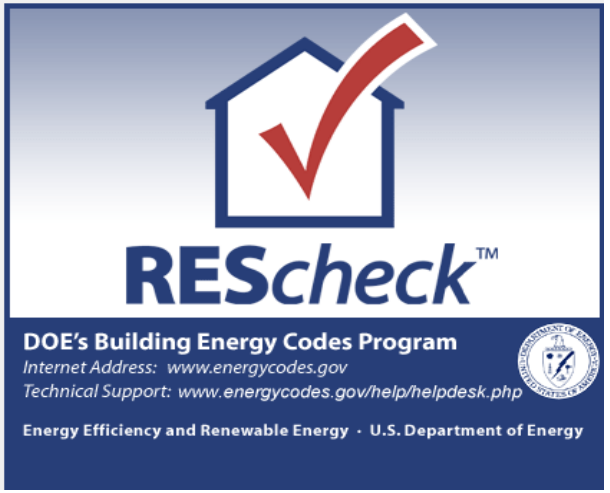
a. Nonfenestration *U*-factors shall be obtained from measurement, calculation or an approved source.
b. When more than half the insulation is on the interior, the mass wall *U*-factors shall be a maximum of 0.17 in Climate Zone 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.
c. Basement wall *U*-factor of 0.360 in warm-humid locations as defined by Figure R301.1 and Table R301.1.



UA < UA
Proposed Standard

$$UA_{Total} = (A \times U_1) + (A \times U_2) + \ldots$$

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2009 IECC*	6	0.33	0.60	NR	49	21 or 13+5[h]	15/19	30[g]	15/19	10, 4 ft	10/19
2012 IECC*	6	0.32	0.55	NR	49	21 or 13+5[h]	15/20	30[g]	15/19	10, 4 ft	15/19
2012 IECC	6	0.32	0.55	NR	49	20+5 or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19

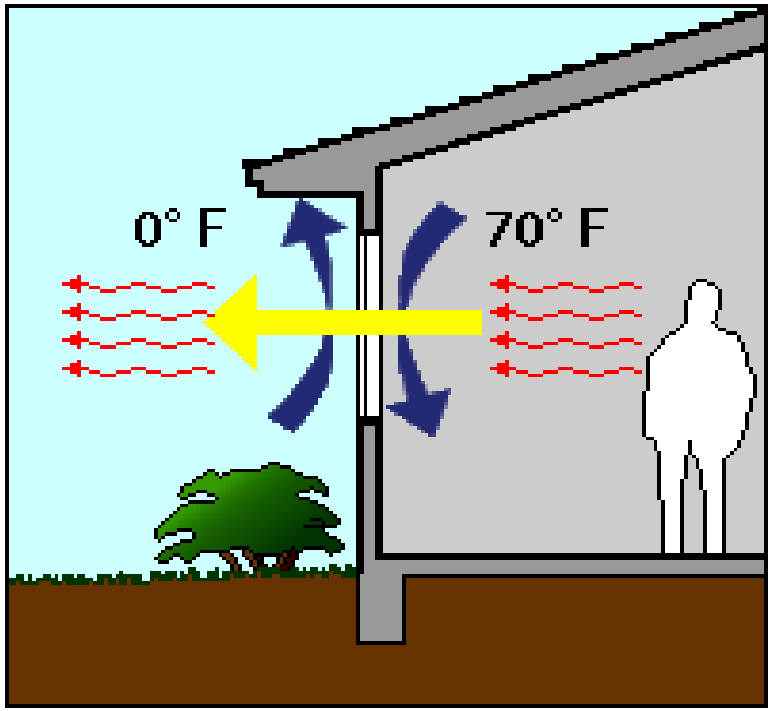
* - With Montana Amendments

Window U-Factor

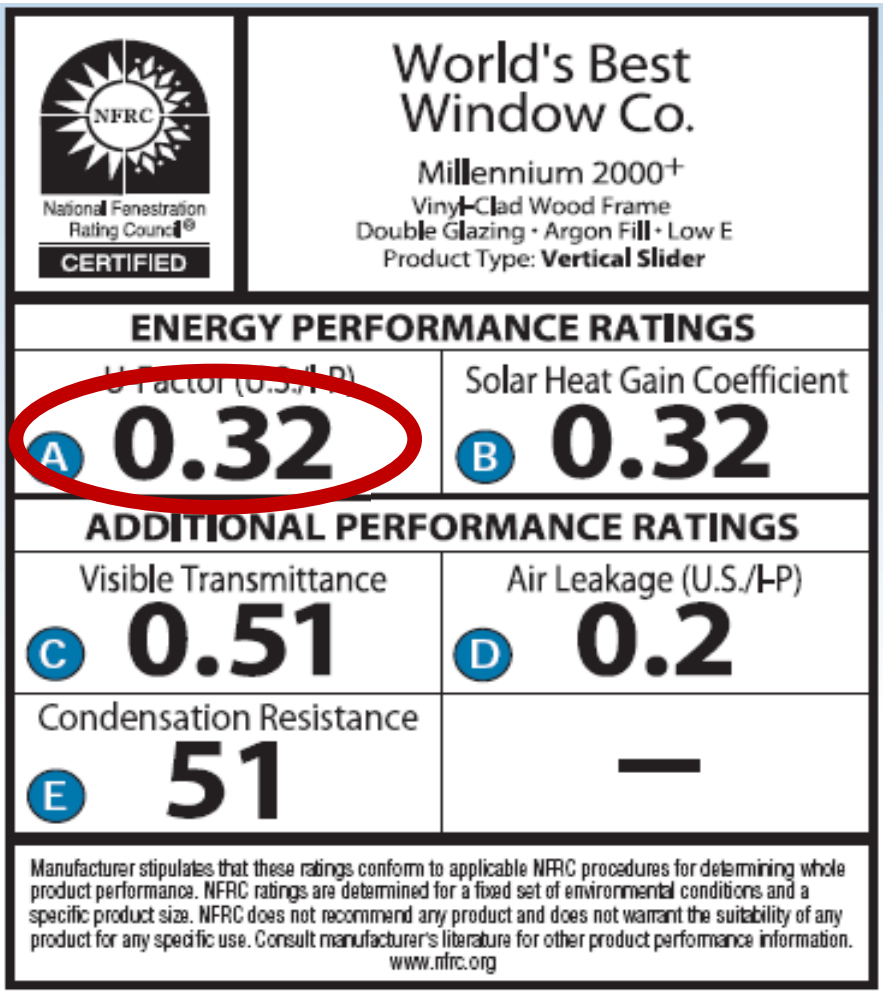
R402.1.1

from 0.32 U-Factor to 0.33

Lower means less heat loss.



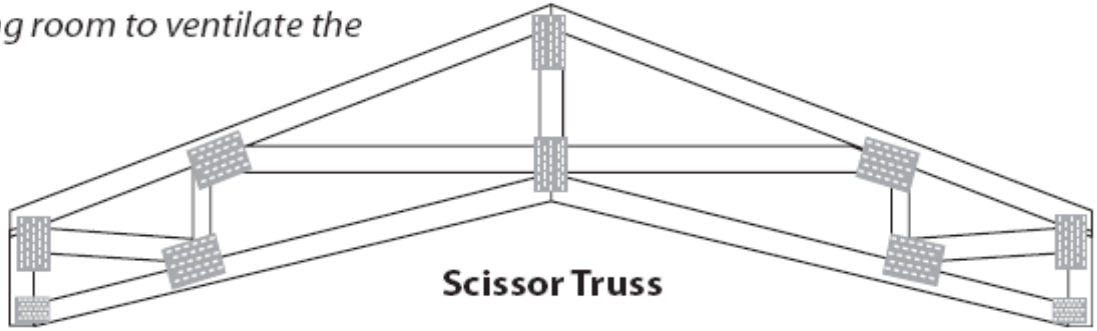
Source: **www.nfrc.org**

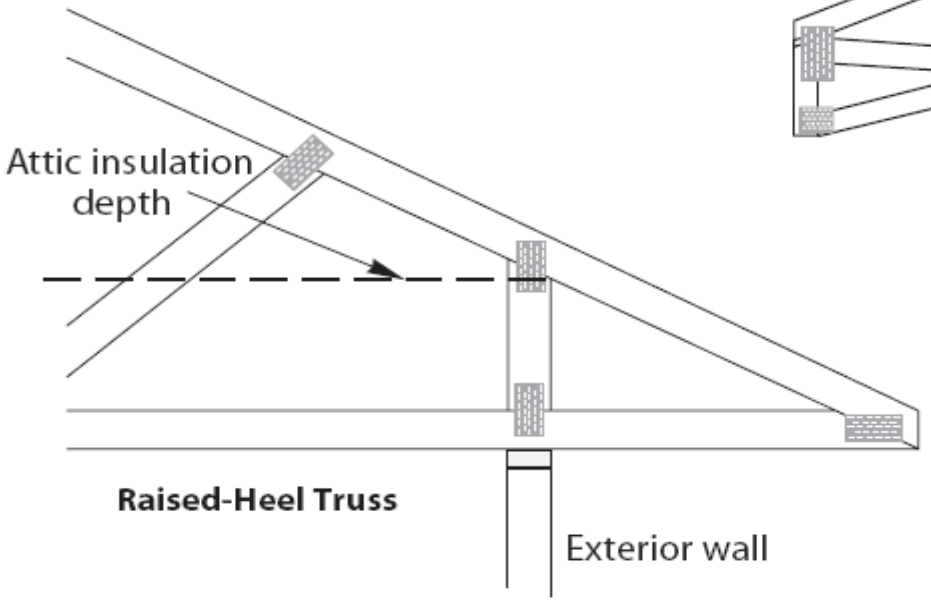


Energy Trusses Allow R-38

R402.1.1

Scissor trusses solve the problem of how to insulate a cathedral ceiling while allowing room to ventilate the insulated space.



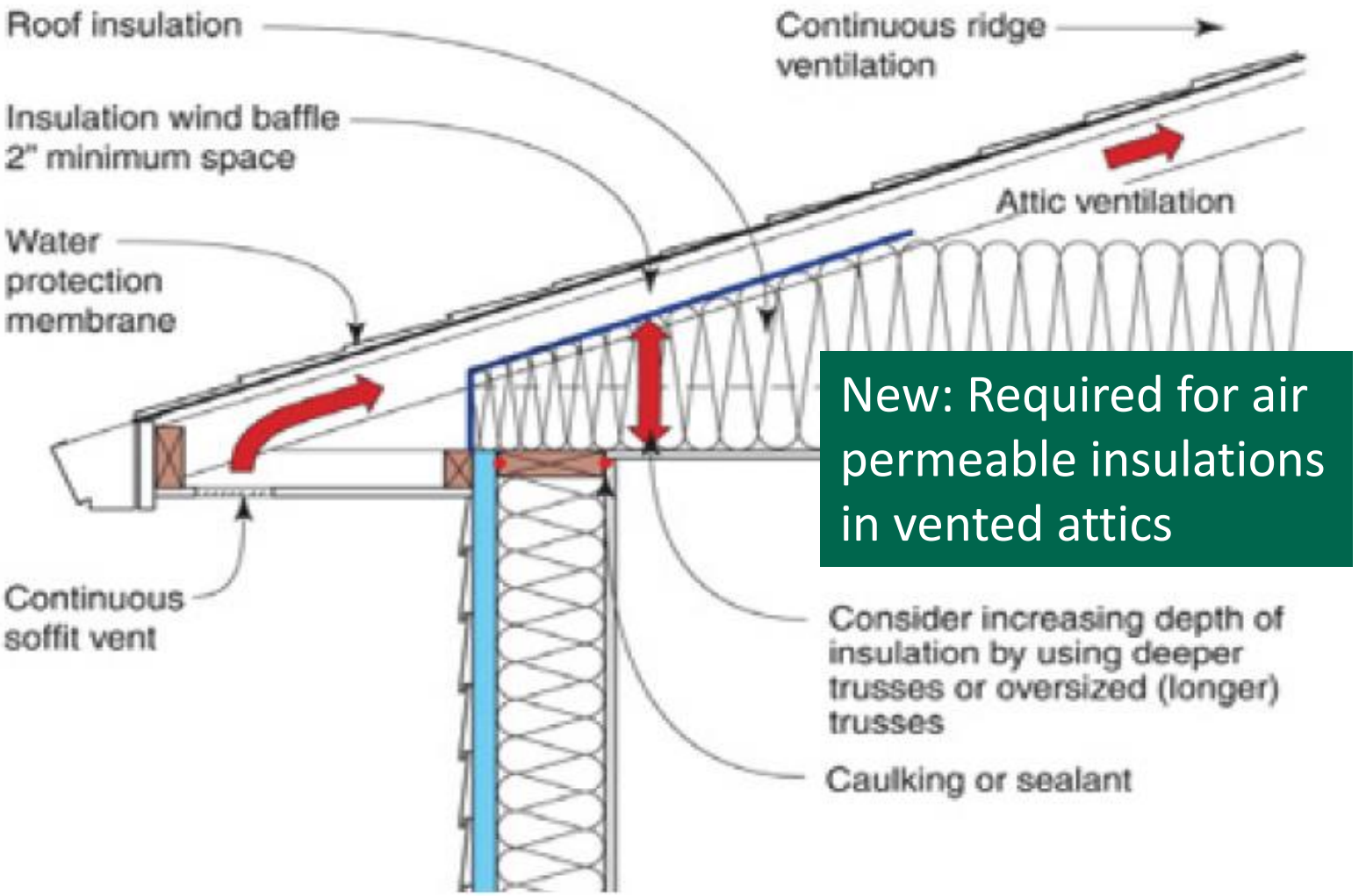


Raised-heel trusses allow the full depth of attic insulation to extend over the top of the exterior wall.

Source - **Residential Energy**

Eave Baffles Required

R402.2.3



New: Required for air permeable insulations in vented attics

Source: USDOE Building Technologies Program, Introduction to Building Systems Performance: Houses That Work II

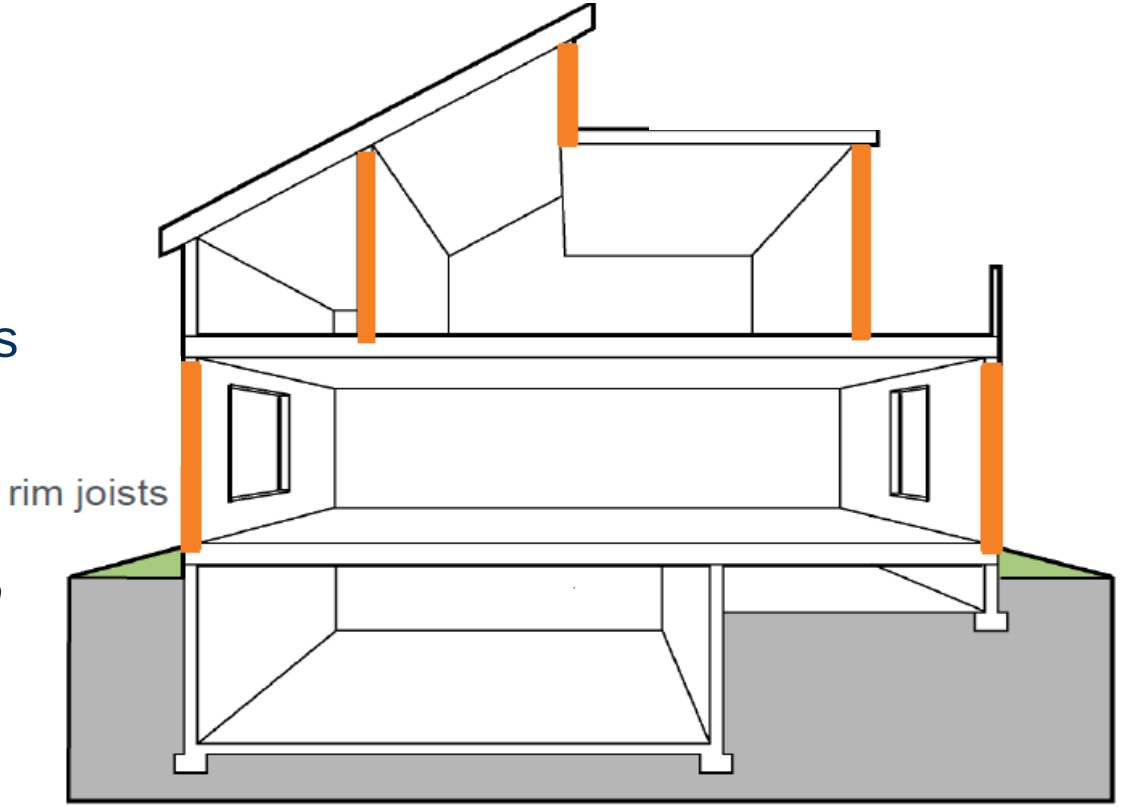
Wood Frame Wall R-Value

R402.1.1

From R21 or R13+R5 R-Value to No Change

2012 IECC ~~R20+R5 or R13+R10~~

- Exterior above-grade walls
- Attic kneewalls
- Skylight shaft walls
- Perimeter joists
- Garage walls *(shared with conditioned space)*



Mass Walls

R402.2.5

Concrete block

Concrete

ICF

Masonry Cavity

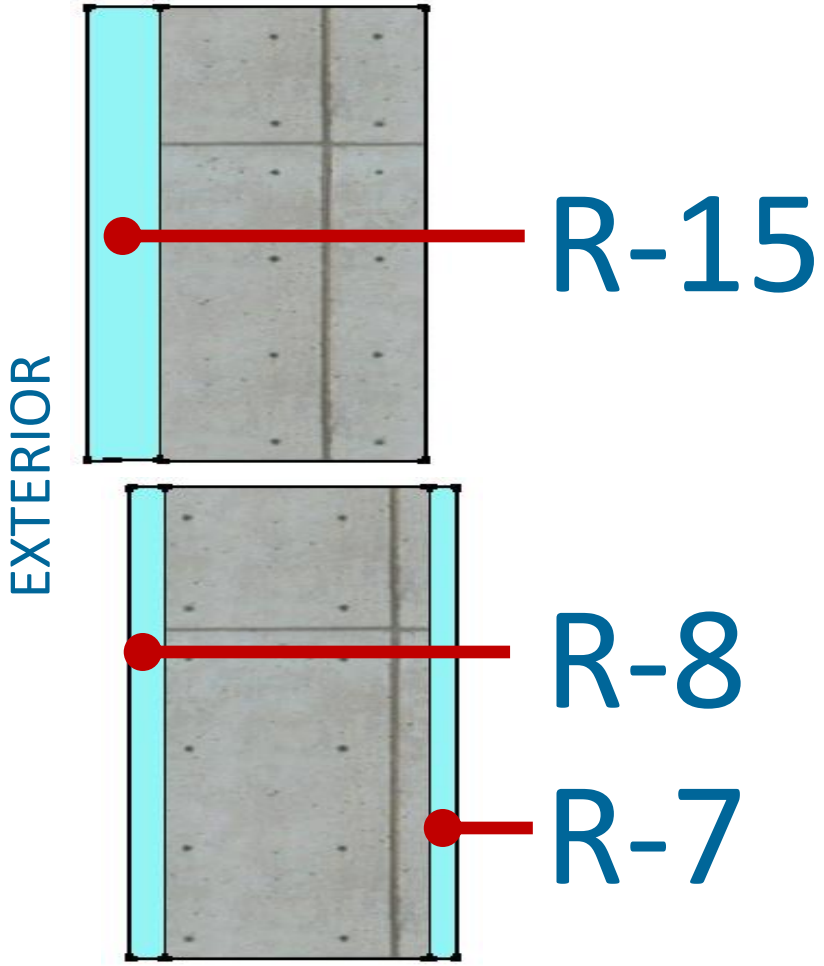
Brick

Earth

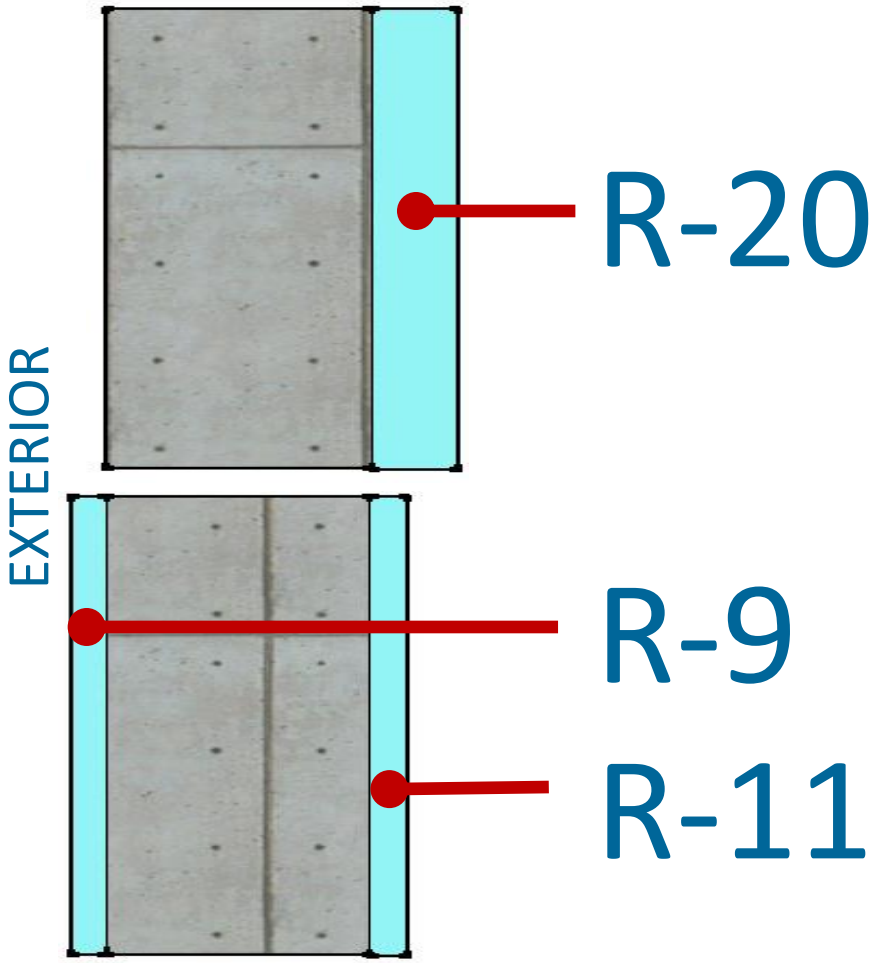
Solid Timber/Logs

Mass Walls

R402.2.5



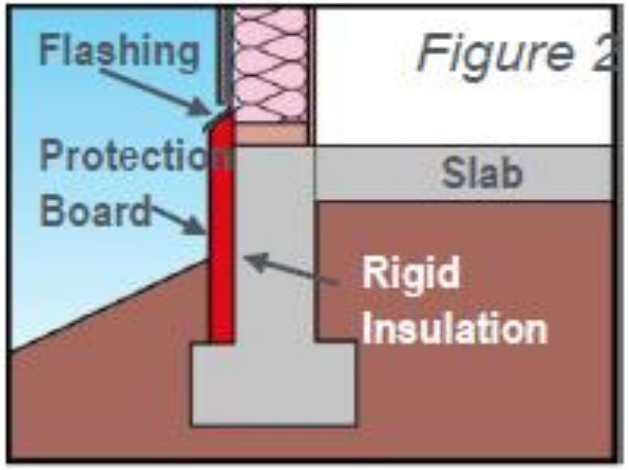
R-15 If More Than Half of Insulation on the Exterior



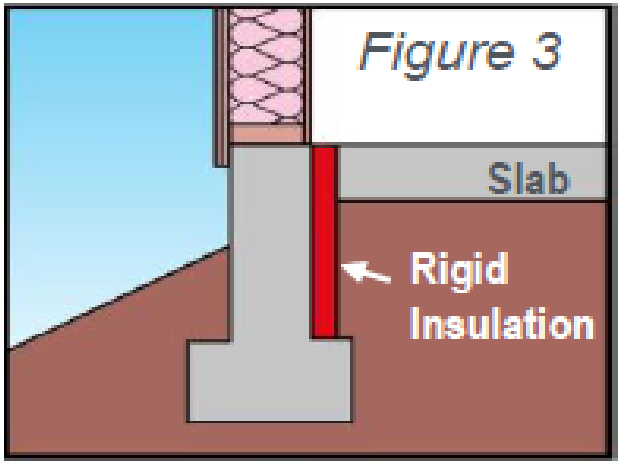
R-20 More Than Half of Insulation on the Interior

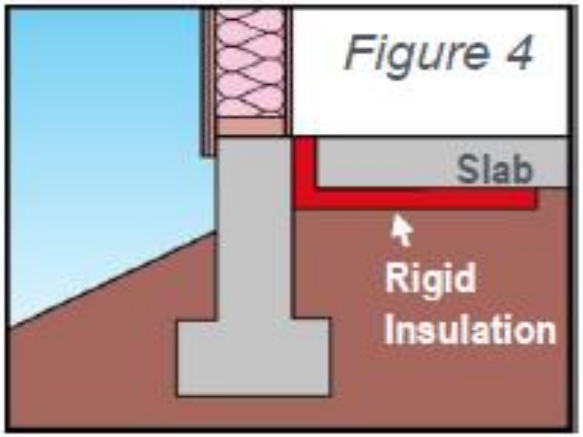
Slab Insulation

R402.2.9



R-10 for 4’ Vertical or Horizontal
Add R-5 if the slab has radiant heat

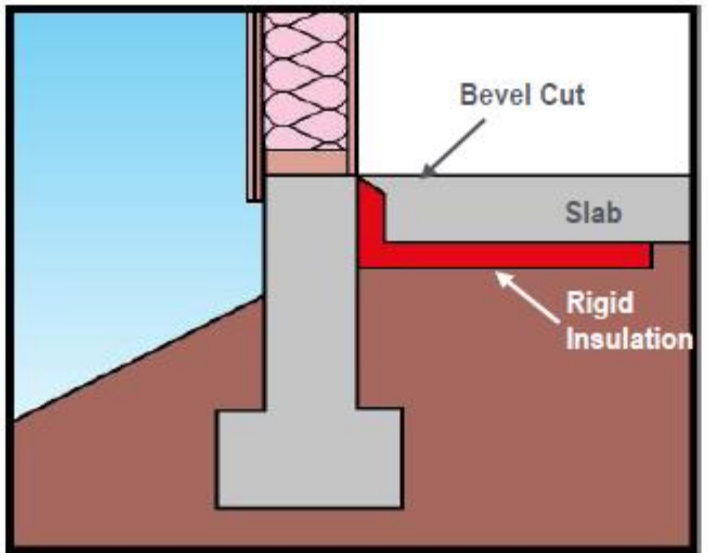




Source: USDOE Building Energy Codes University

Slab Insulation

R402.2.9



Source: USDOE Building Energy Codes University

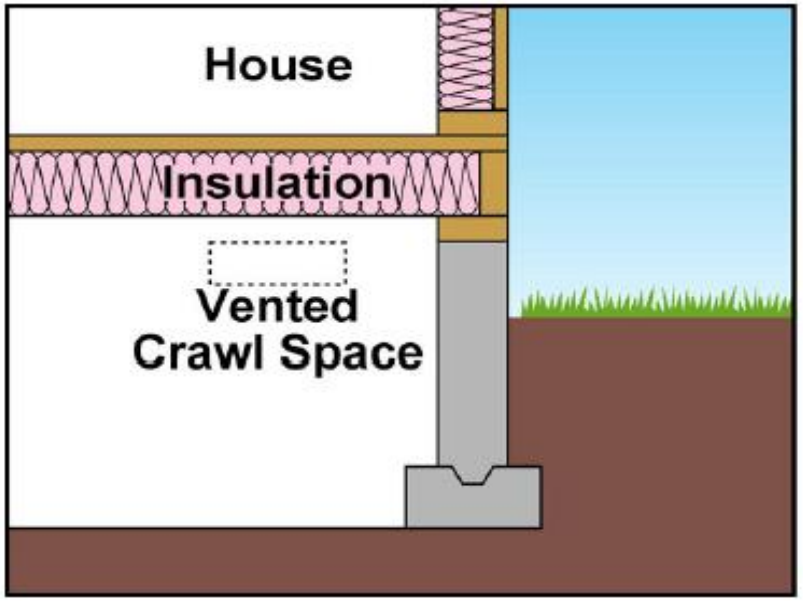
Unvented Crawlspace Wall

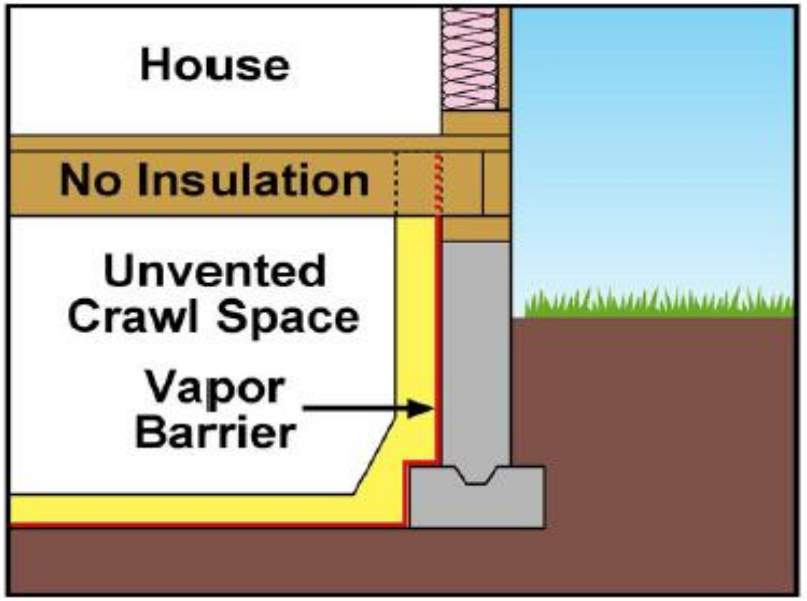
R402.1.1

From R10 / R19 R-Value to R15 / R19

(Continuous / Cavity)

- Must choose to insulate either floor or walls
- Either mechanically vented or minimally conditioned (*IRC)*
- Continuous Class I vapor retarder at exposed earth



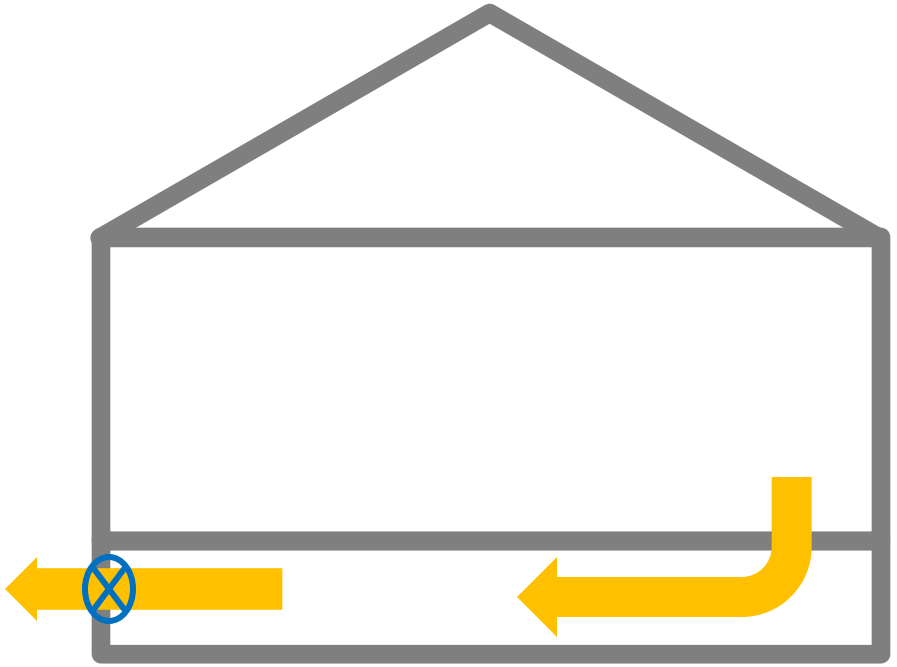


Unvented Crawlspaces – Two Design Options

IRC R408.3

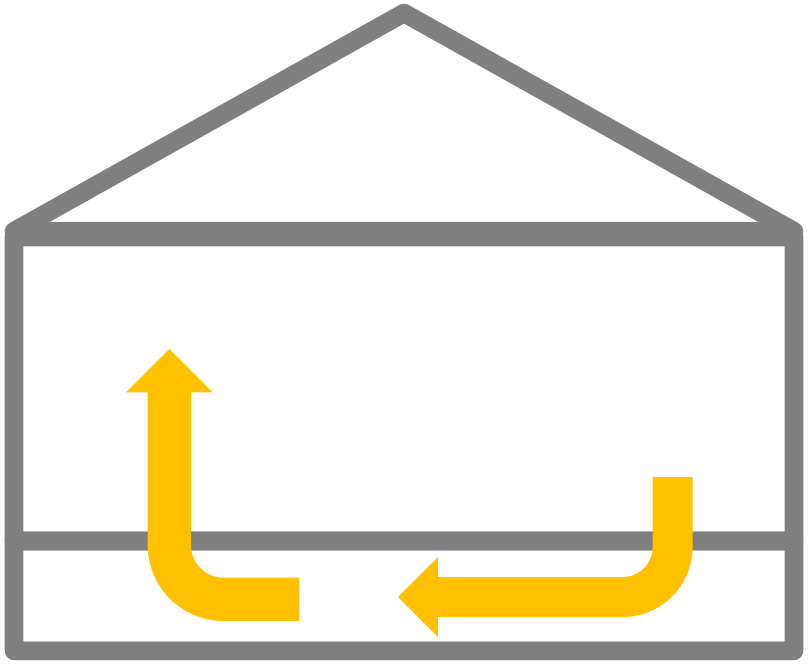
Continuous **Exhaust** to Exterior

- 1 CFM/50 SF Crawlspace Area
- Air Pathway to Common Area



Conditioned Air Supply

- 1 CFM/50 SF Crawlspace Area
- Air Pathway to Common Area



Air Leakage (Mandatory)

R402.4

Thermal envelope must comply with both:

Testing (402.4.1.2)

+

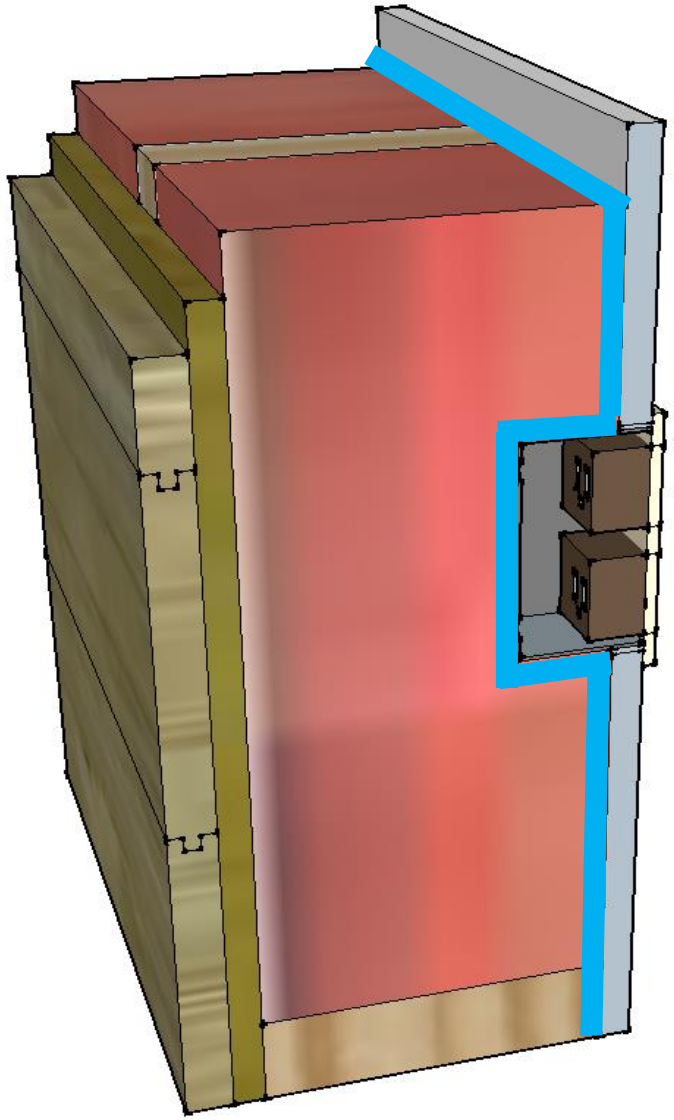
Air Barrier and Insulation Installation (Table R402.4.1)

COMPONENT	CRITERIA*
Air barrier and thermal barrier	A continuous air barrier shall be installed in the building envelope. Exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed. Air-permeable insulation shall not be used as a sealing material.
Ceiling/attic	The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop down stair or knee wall doors to unconditioned attic spaces shall be sealed.
Walls	Corners and headers shall be insulated and the junction of the foundation and sill plate shall be sealed. The junction of the top plate and top of exterior walls shall be sealed. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier. Knee walls shall be sealed.
Windows, skylights and doors	The space between window/door jambs and framing and skylights and framing shall be sealed.
Rim joists	Rim joists shall be insulated and include the air barrier.
Floors (including above-garage and cantilevered floors)	Insulation shall be installed to maintain permanent contact with underside of subfloor decking. The air barrier shall be installed at any exposed edge of insulation.
Crawl space walls	Where provided in lieu of floor insulation, insulation shall be permanently attached to the crawlspace walls. Exposed earth in unvented crawl spaces shall be covered with a Class I vapor retarder with overlapping joints taped.
Shafts, penetrations	Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed.
Narrow cavities	Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space.
Garage separation	Air sealing shall be provided between the garage and conditioned spaces.
Recessed lighting	Recessed light fixtures installed in the building thermal envelope shall be air tight, IC rated, and sealed to the drywall.
Plumbing and wiring	Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring.
Shower/tub on exterior wall	Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating them from the showers and tubs.
Electrical/phone box on exterior walls	The air barrier shall be installed behind electrical or communication boxes or air sealed boxes shall be installed.
HVAC register boots	HVAC register boots that penetrate building thermal envelope shall be sealed to the sub-floor or drywall.
Fireplace	An air barrier shall be installed on fireplace walls. Fireplaces shall have gasketed doors.

"Where required by the code official, testing shall be conducted by an *approved* ~~third~~ party."

Montana Air Barrier

Material(s) assembled and joined together to provide a barrier to air leakage through ***and into*** the building envelope. An air barrier may be a single material or a combination of materials.



Air Barrier and Insulation Installation

Table R402.4.1.1

16 Installation Components

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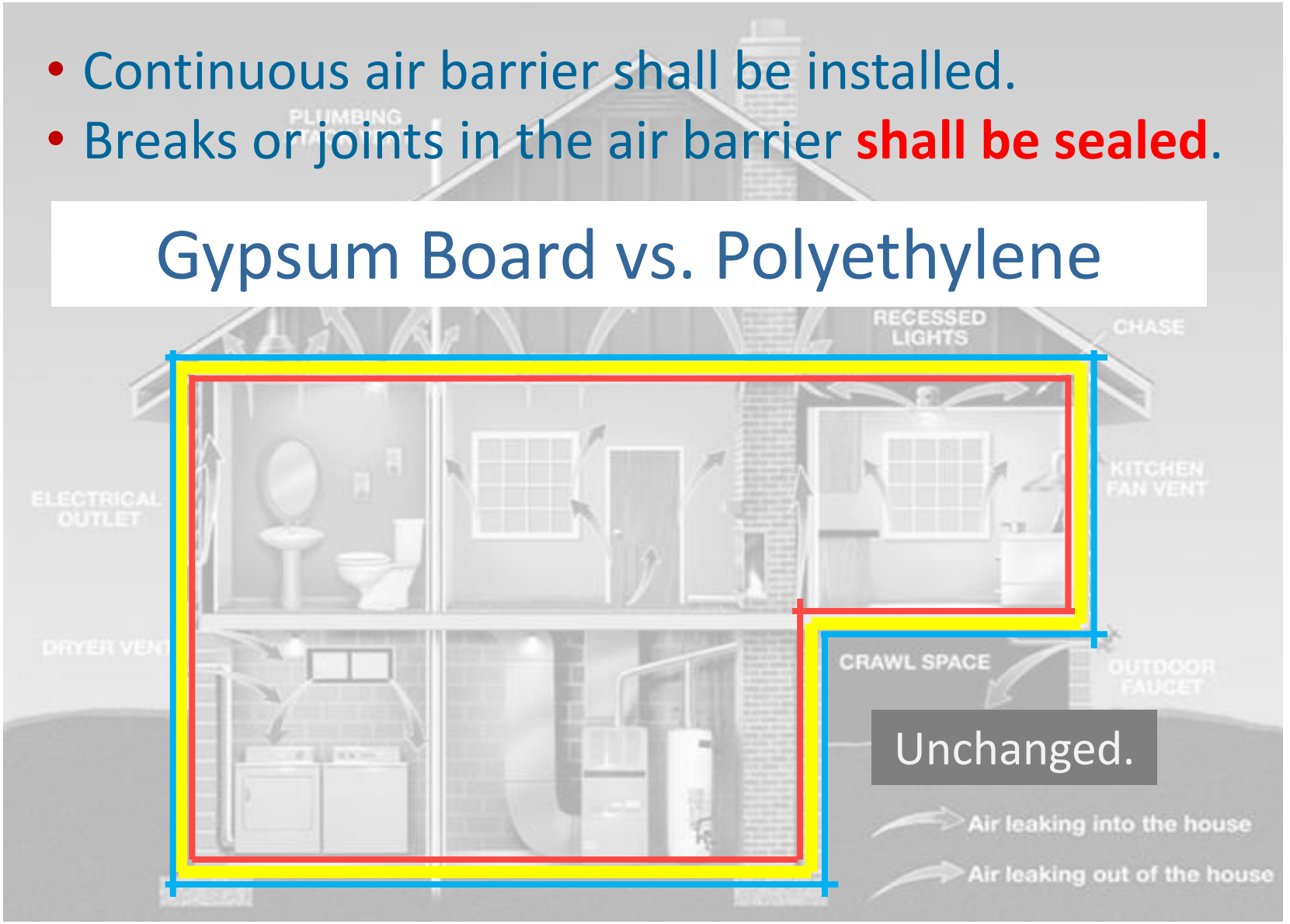
Source: USDOE Vol. 10 Building America
Best Practices Series - Air Sealing

1. Air Barrier and Thermal Barrier

Table R402.4.1.1

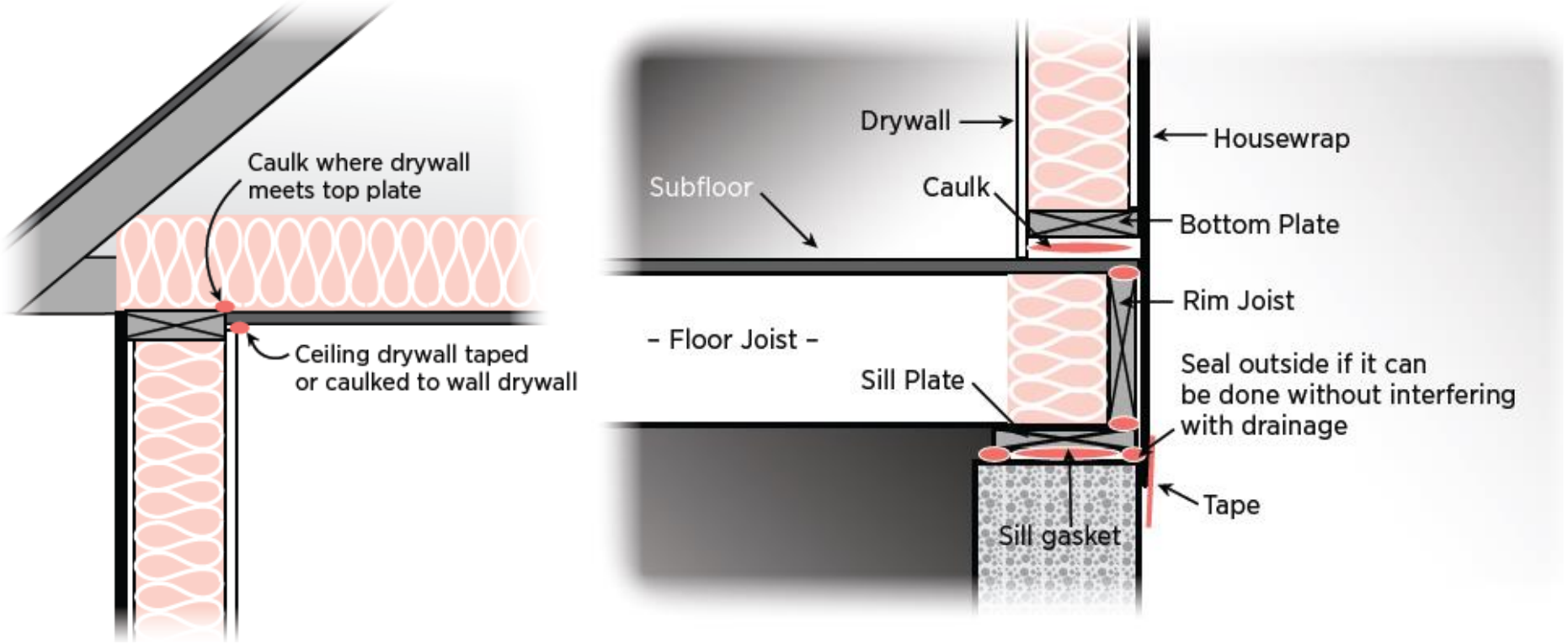
- Continuous air barrier shall be installed.
- Breaks or joints in the air barrier **shall be sealed**.

Gypsum Board vs. Polyethylene



1. Air Barrier and Thermal Barrier

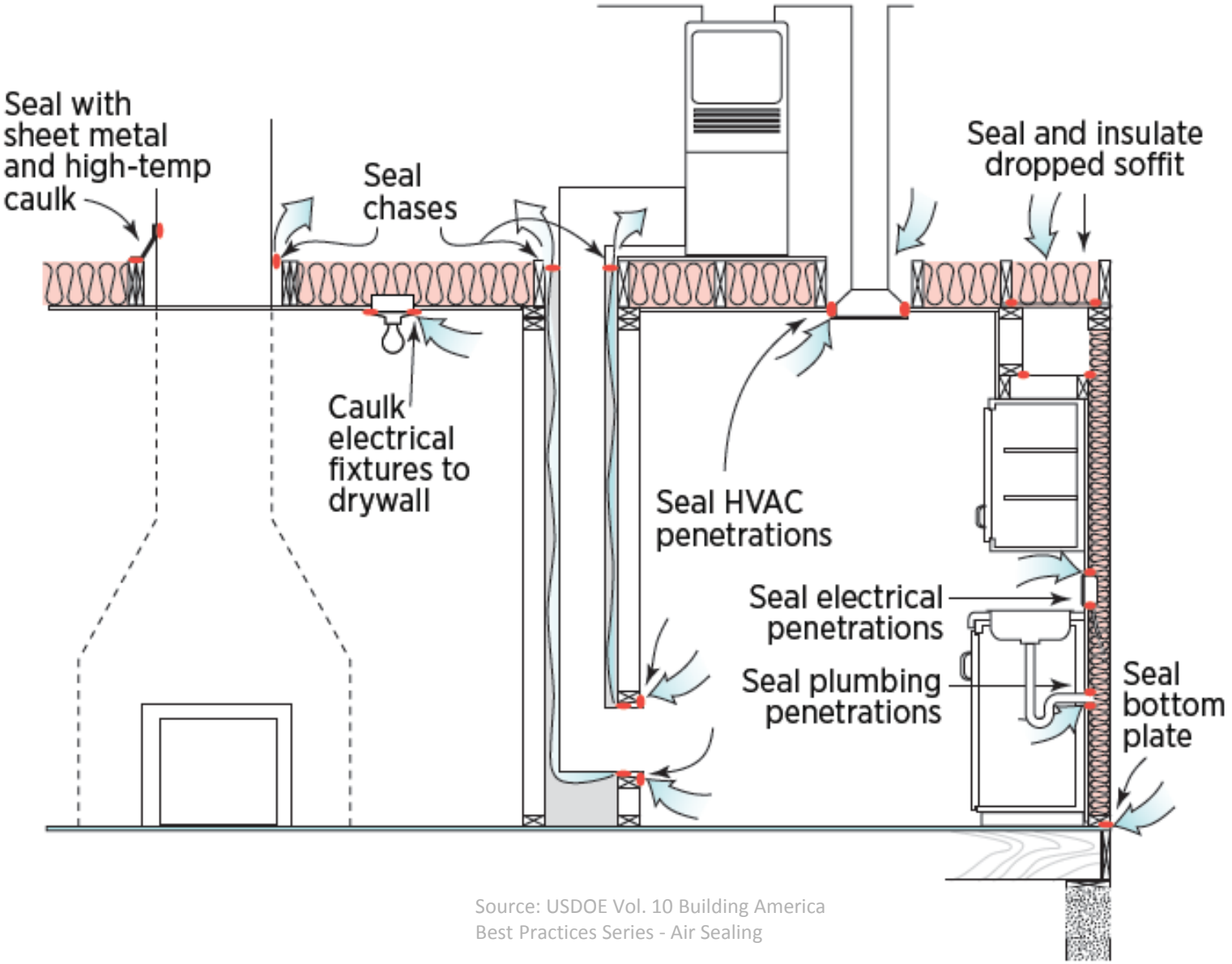
Table R402.4.1.1



Source: USDOE Vol. 10 Building America Best Practices Series - Air Sealing

1. Air Barrier and Thermal Barrier

Table R402.4.1.1

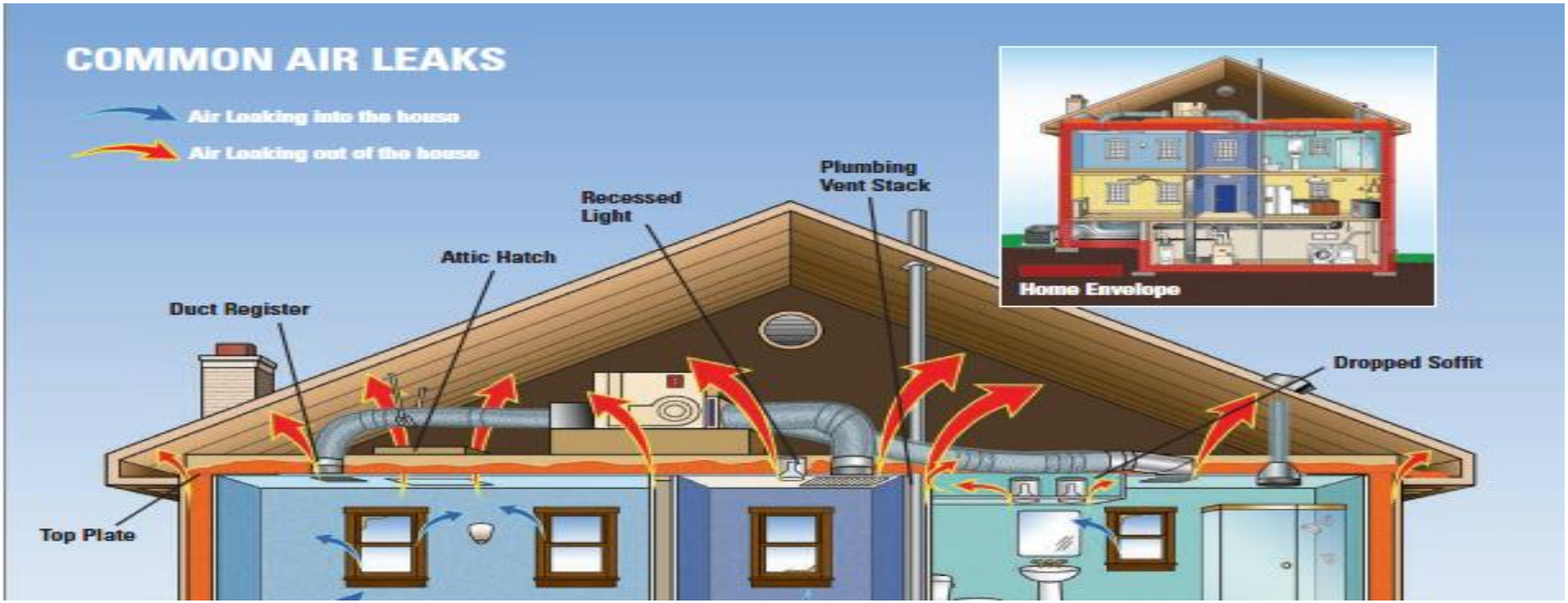


Source: USDOE Vol. 10 Building America Best Practices Series - Air Sealing

2. Ceiling/attic

Unchanged.

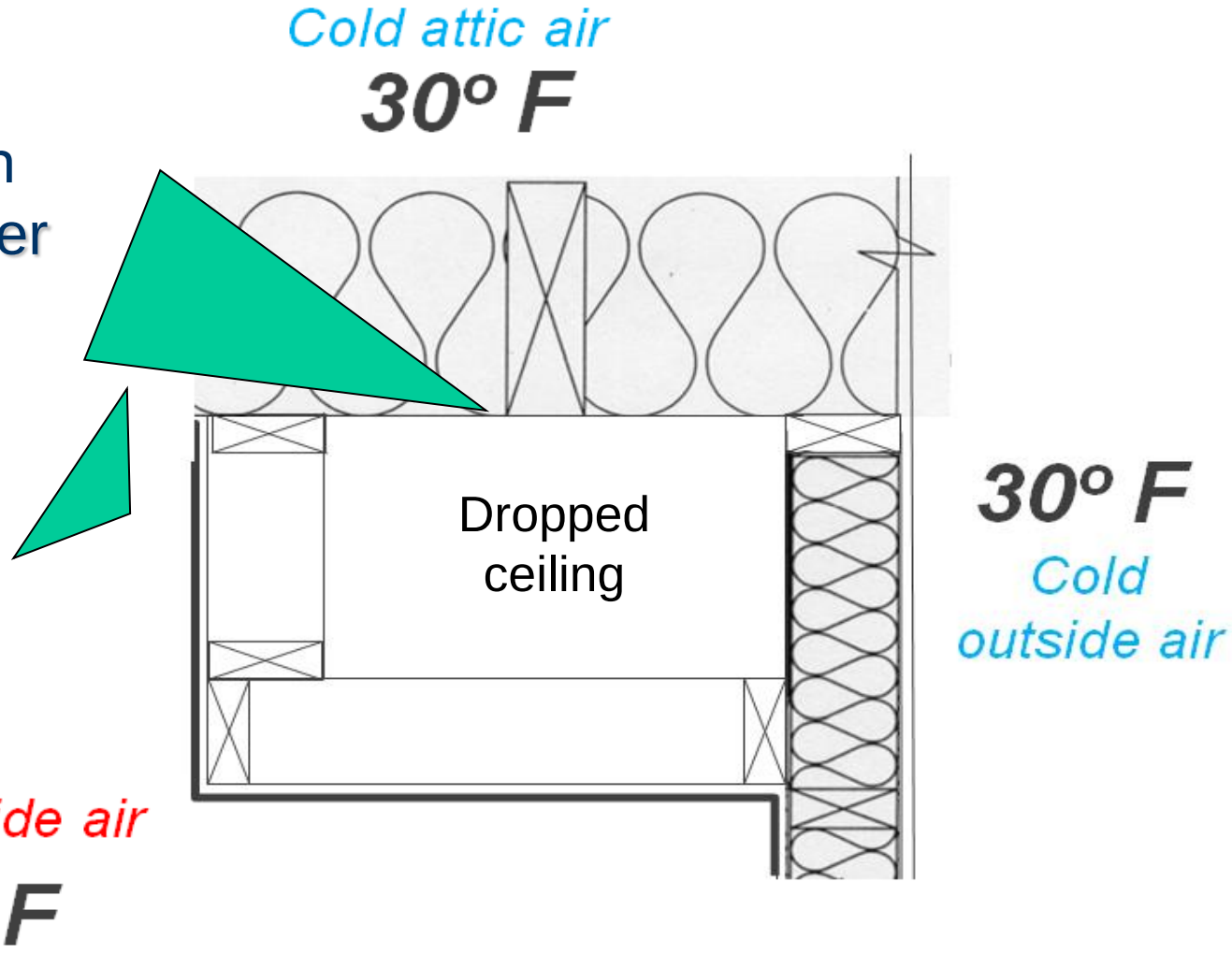
Table R402.4.1.1



CONTROLLING THERMAL FLOW:

WHY ALIGN THE AIR BARRIER?

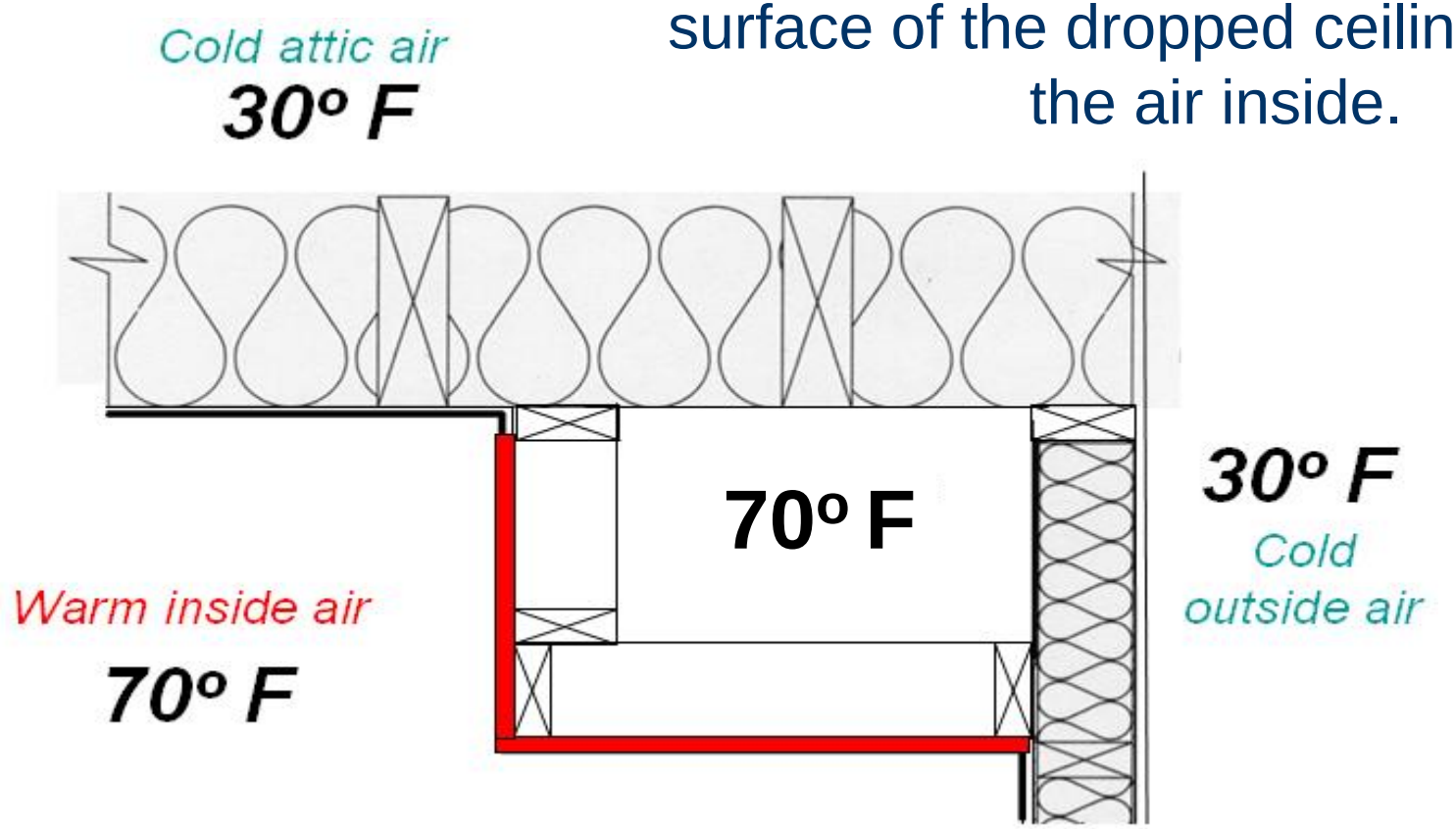
Here's an common example of air barrier misalignment.



CONTROLLING THERMAL FLOW:

WHY ALIGN THE AIR BARRIER?

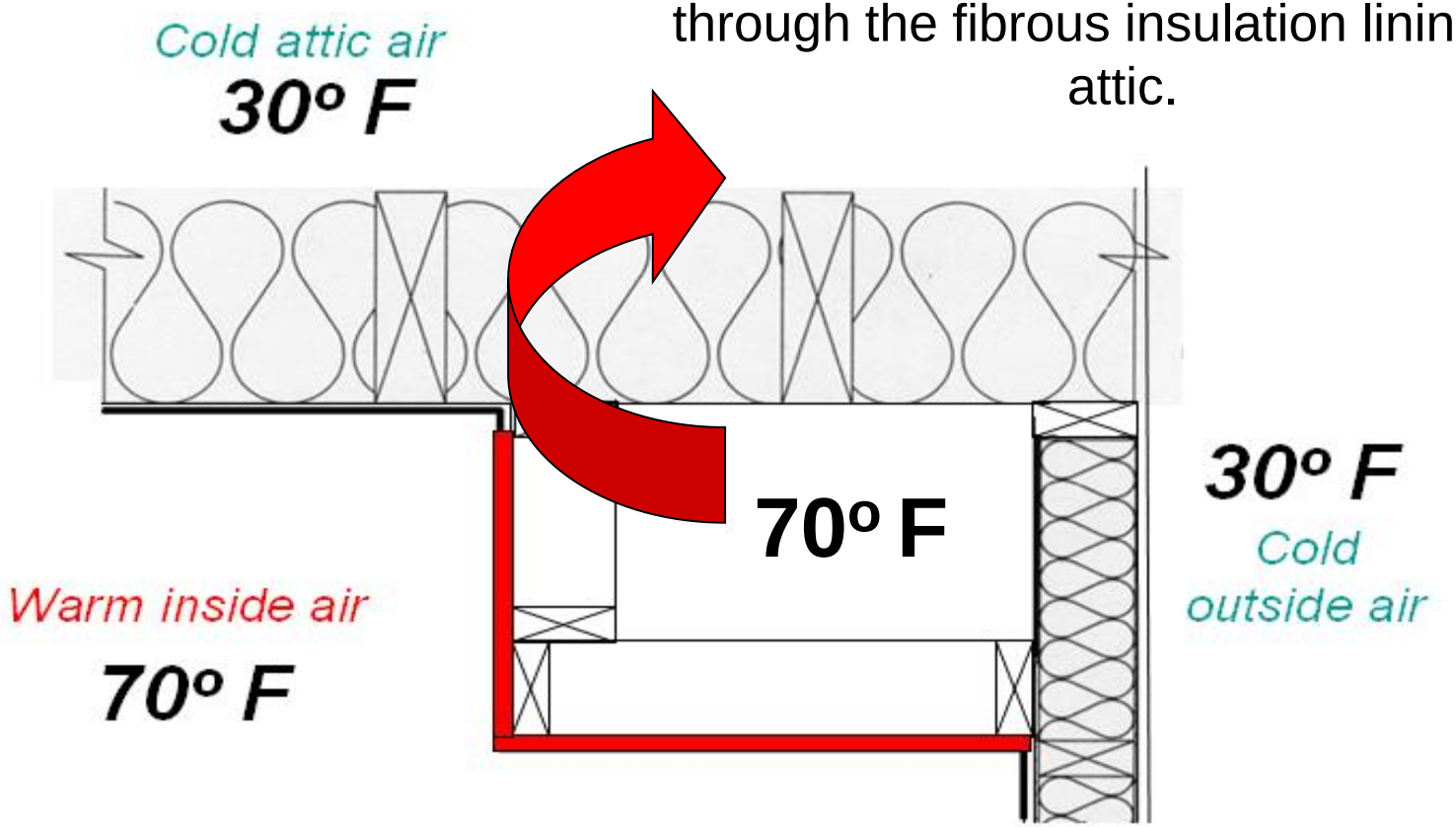
The air barrier (in this case, the drywall) doesn't insulate, so radiation will heat the surface of the dropped ceiling, warming the air inside.



CONTROLLING THERMAL FLOW:

WHY ALIGN THE AIR BARRIER?

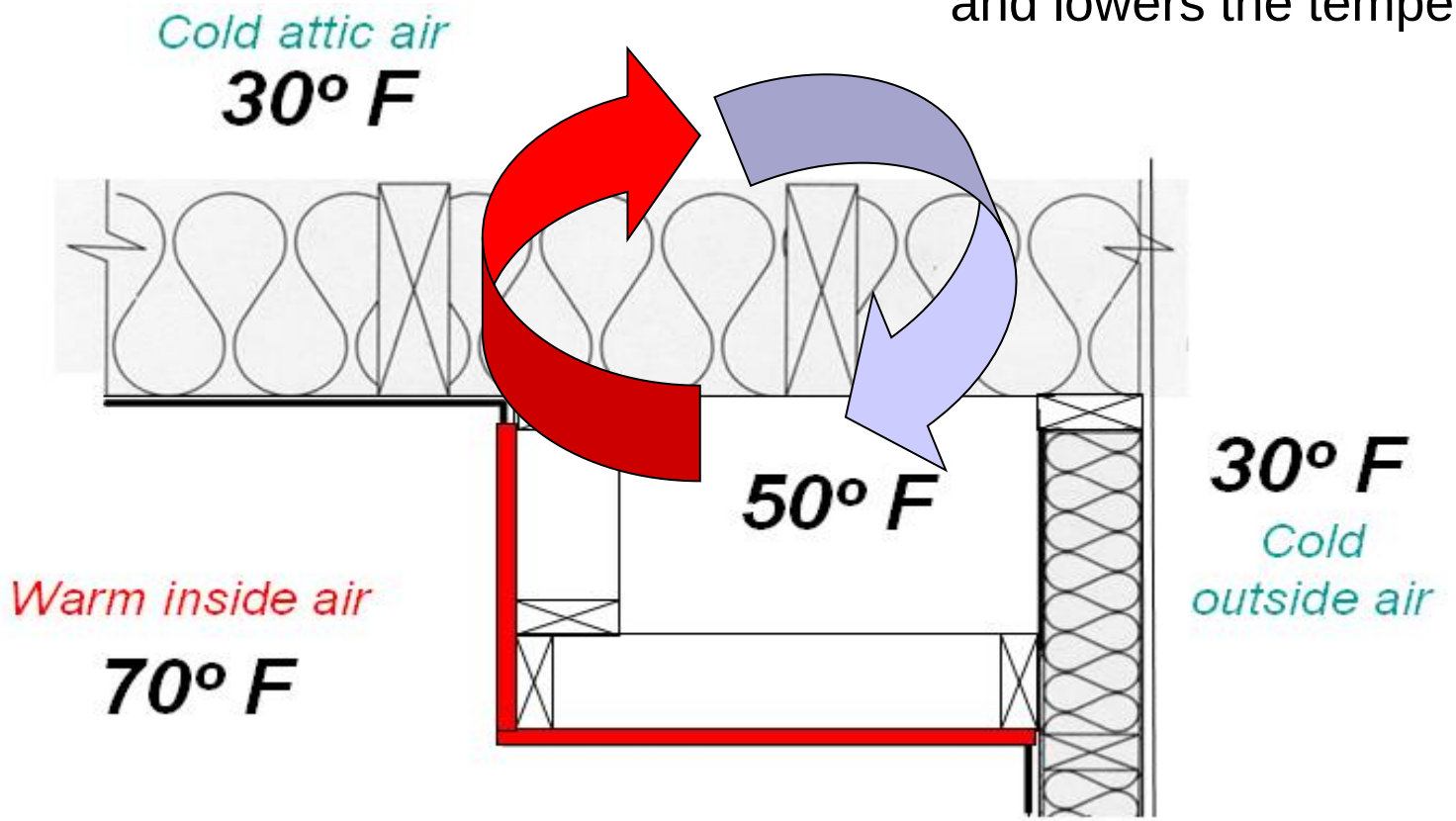
The warm surface of the dropped ceiling created a convective loop through the fibrous insulation lining the attic.



CONTROLLING THERMAL FLOW:

WHY ALIGN THE AIR BARRIER?

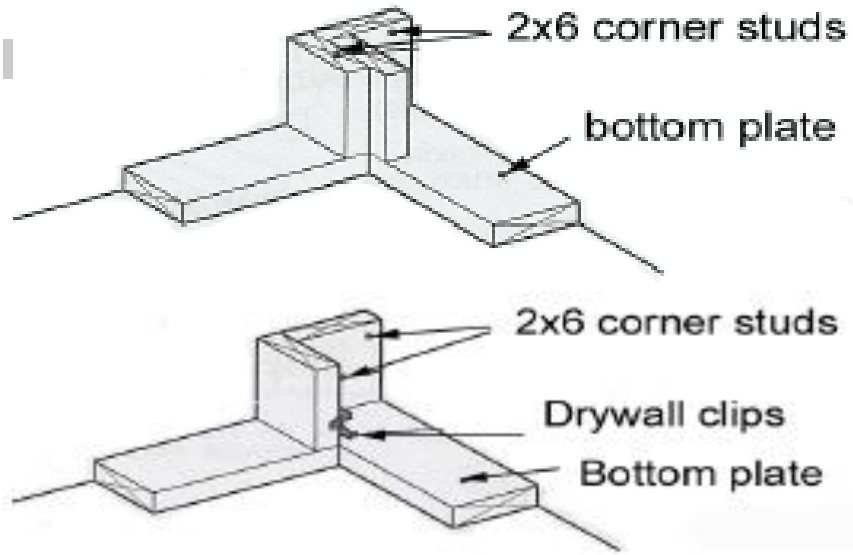
As warm air flows into the attic, cold air flows back out (into the dropped ceiling) and lowers the temperature.



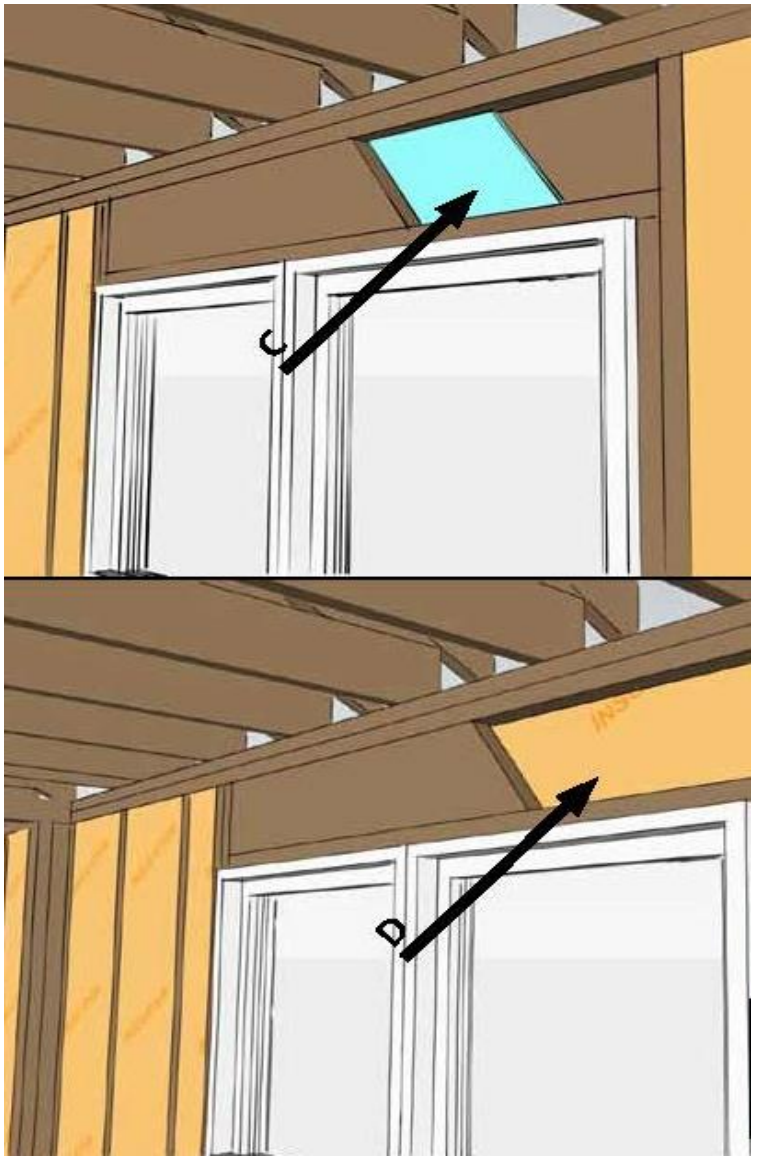
3. Walls

Unchanged.

Table R402.4.1.1



Source: ENERGY STAR New Homes

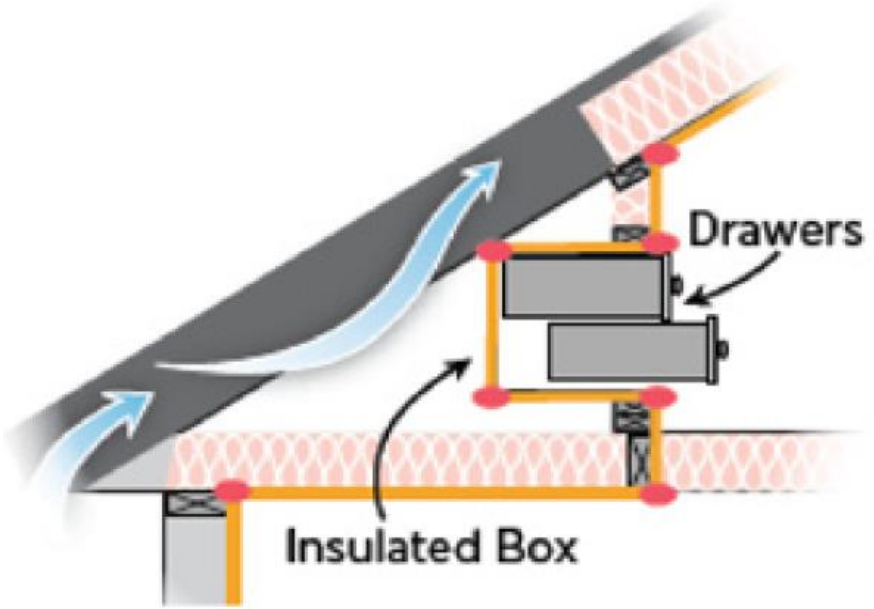


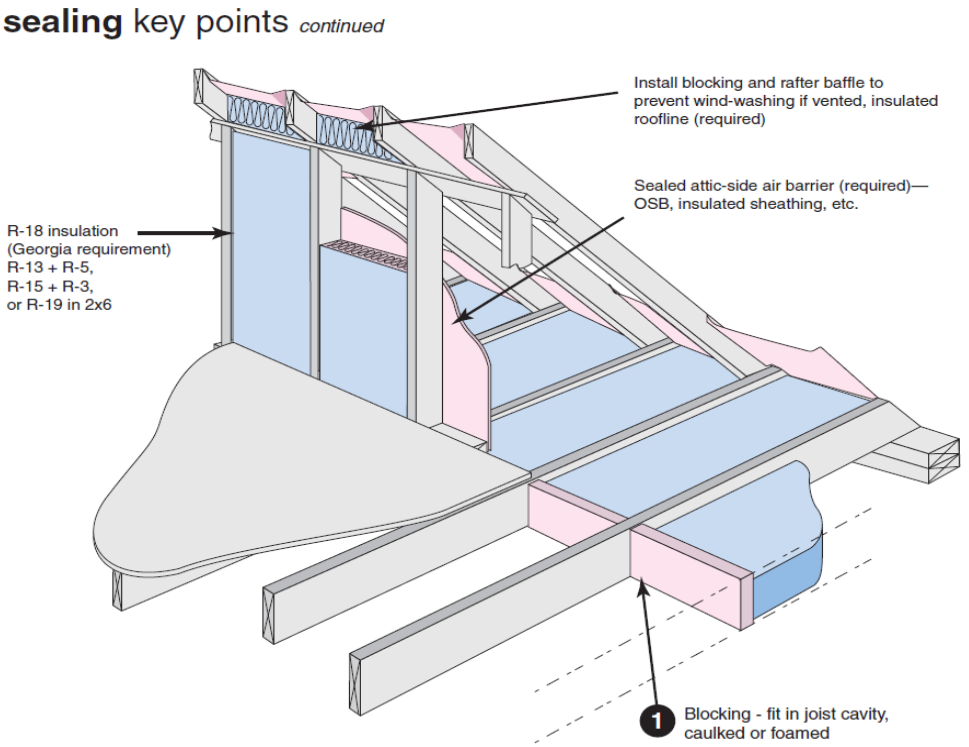
Source: ENERGY STAR New Homes

3. Walls

New

Table R402.4.1.1



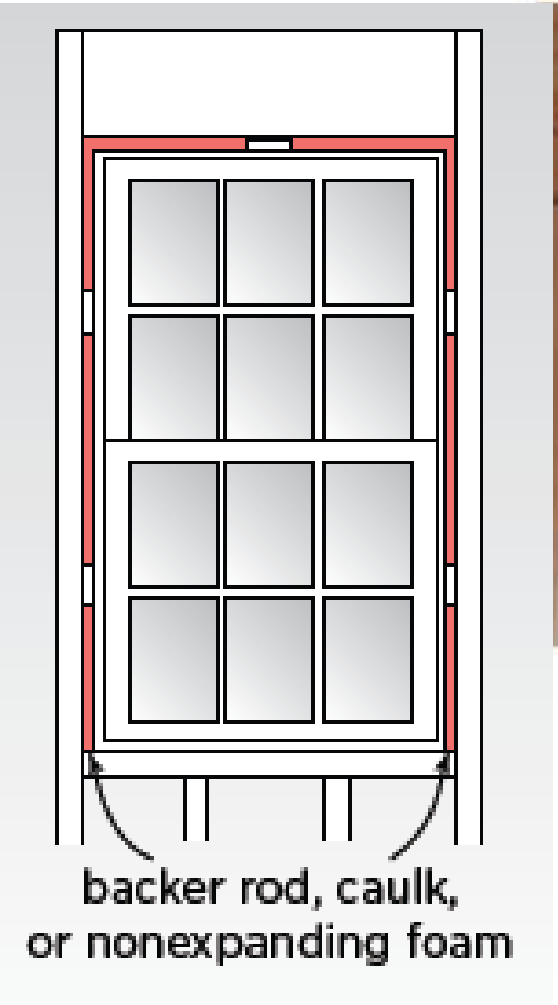


Source: USDOE Vol. 10 Building America Best Practices Series - Air Sealing

Appendix 2009 IECC

4. Windows, Skylights, and Doors

Table R402.4.1.1



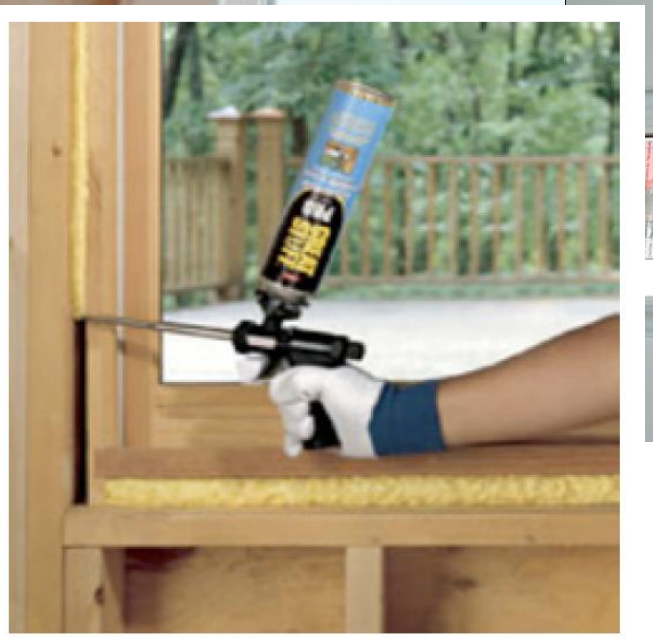


Image: Sprayfoam.com

Source: USDOE Building Energy Codes University

Unchanged.

Source: ENERGY STAR New Homes

5. Rim Joists

Unchanged. Table R402.4.1.1

5. Rim Joists

Table R402.4.1.1

6. Floors

Unchanged.

Table R402.4.1.1

7. Crawl Space Walls

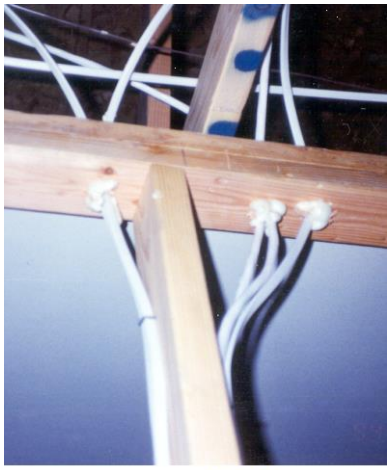
Unchanged.

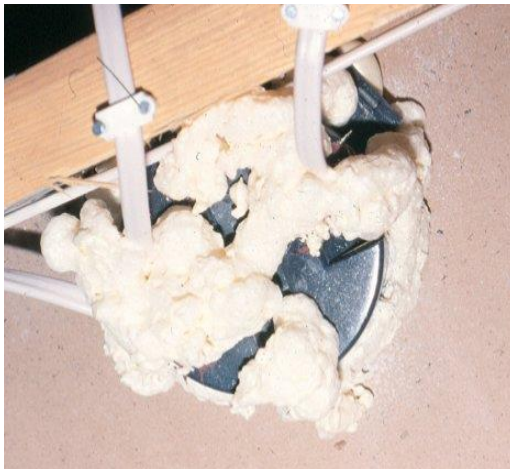
Table R402.4.1.1

8. Shafts, Penetrations

Unchanged. **Table R402.4.1.1**

Source: USDOE Building Energy Codes University





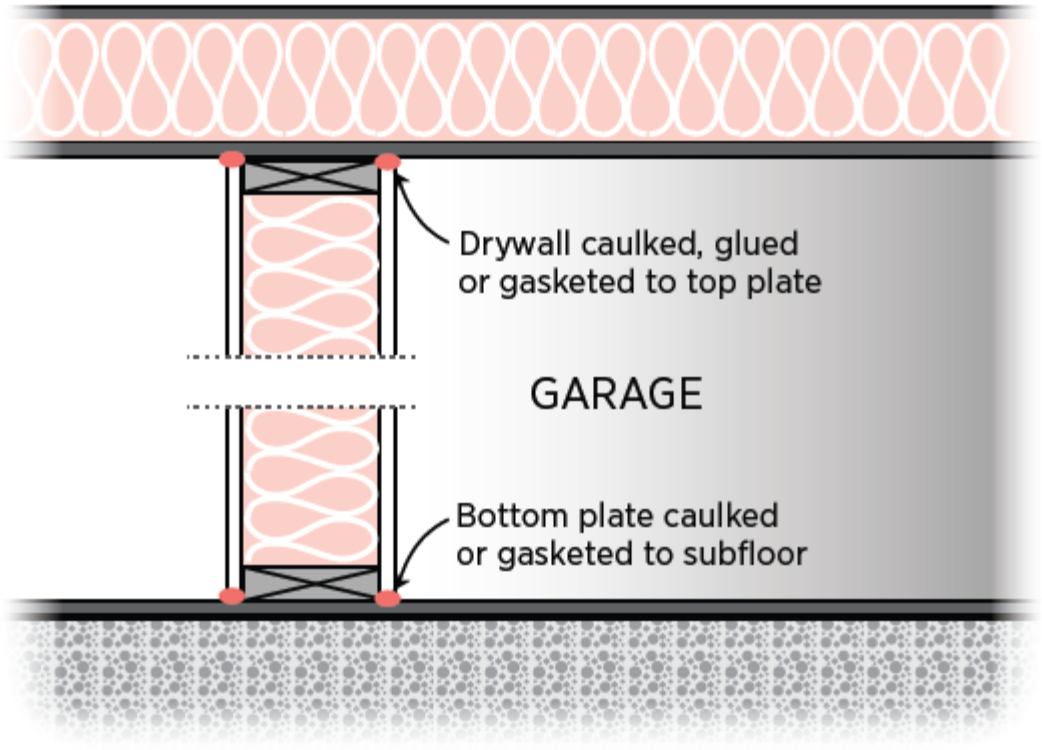
Source: USDOE Building Technologies Program, Whole-House Energy Savings in Cold and Very Cold Climates

9. Narrow Cavities

Unchanged. Table R402.4.1.1

10. Garage Separation

Unchanged. Table R402.4.1.1

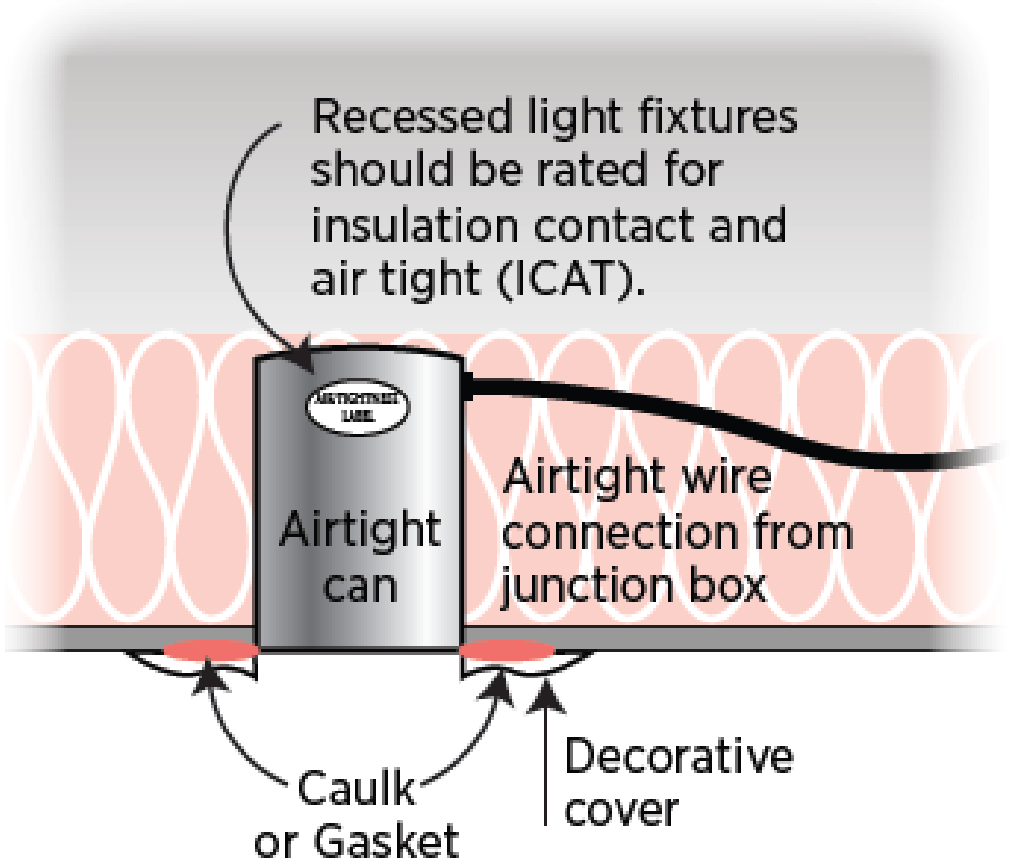


Source: USDOE Vol. 10 Building America Best Practices Series - Air Sealing

Source: ENERGY STAR New Homes

11. Recessed Lighting

Unchanged. Table R402.4.1.1



Source: USDOE Vol. 10 Building America Best Practices Series - Air Sealing

Source: ENERGY STAR New Homes

12. Plumbing and Wiring

Table R402.4.1.1

Does Not Comply with Code

Source: USDOE Vol. 10 Building America Best Practices Series - Air Sealing

13. Shower/Tub on Exterior Wall

Table R402.4.1.1

Unchanged.

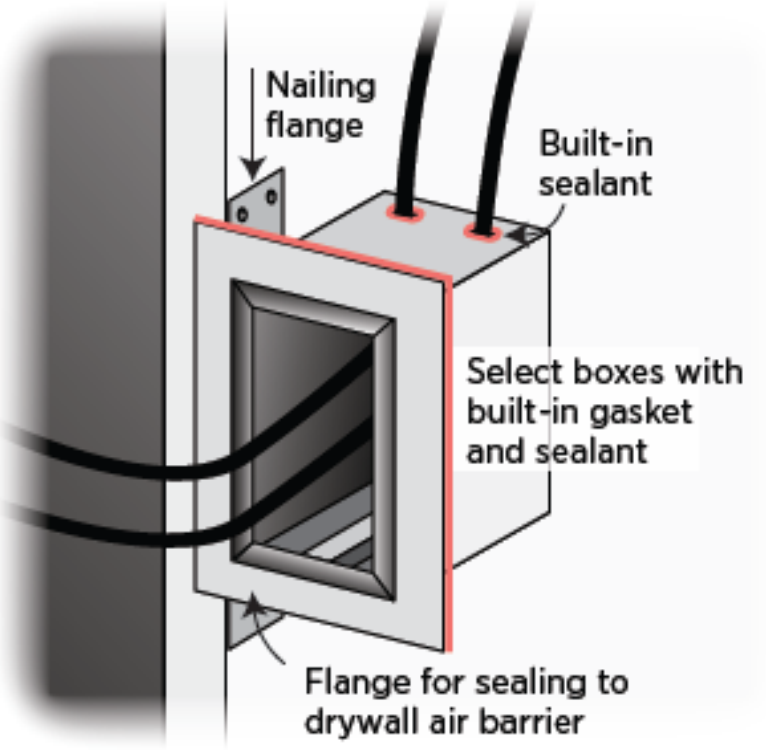
Source: ENERGY STAR New Homes

Source: ENERGY STAR New Homes

14. Electrical/Phone Box

Unchanged. Table R402.4.1.1

Source: USDOE Building Energy Codes University



Seal all electric outlets and switches with foam sealant, or select boxes with built-in sealant or gaskets.

Source: USDOE Vol. 10 Building America Best Practices Series - Air Sealing

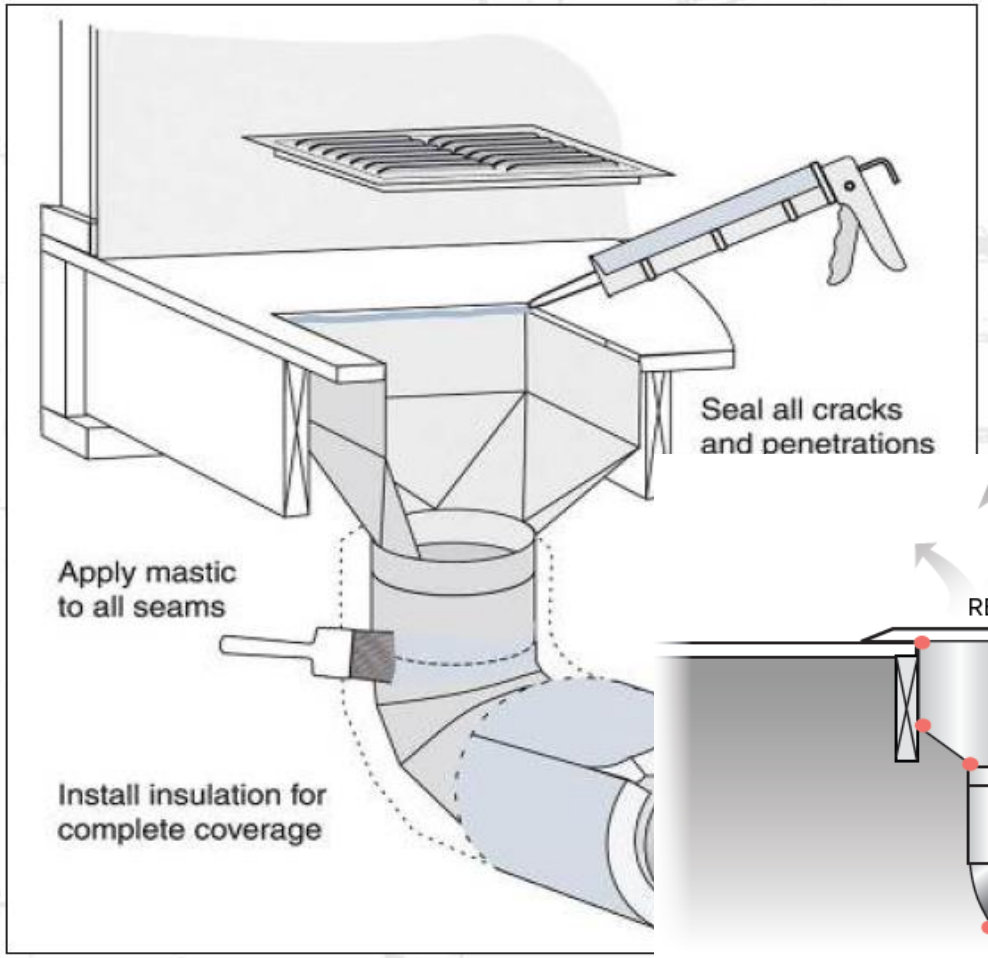
AIR SEALING

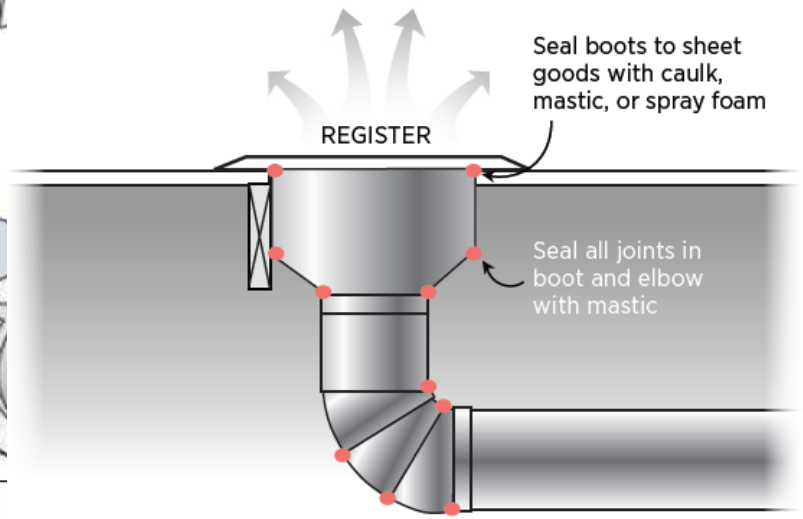
Courtesy of Building Science Corp.

15. HVAC Register Boots

Unchanged.

Table R402.4.1.1





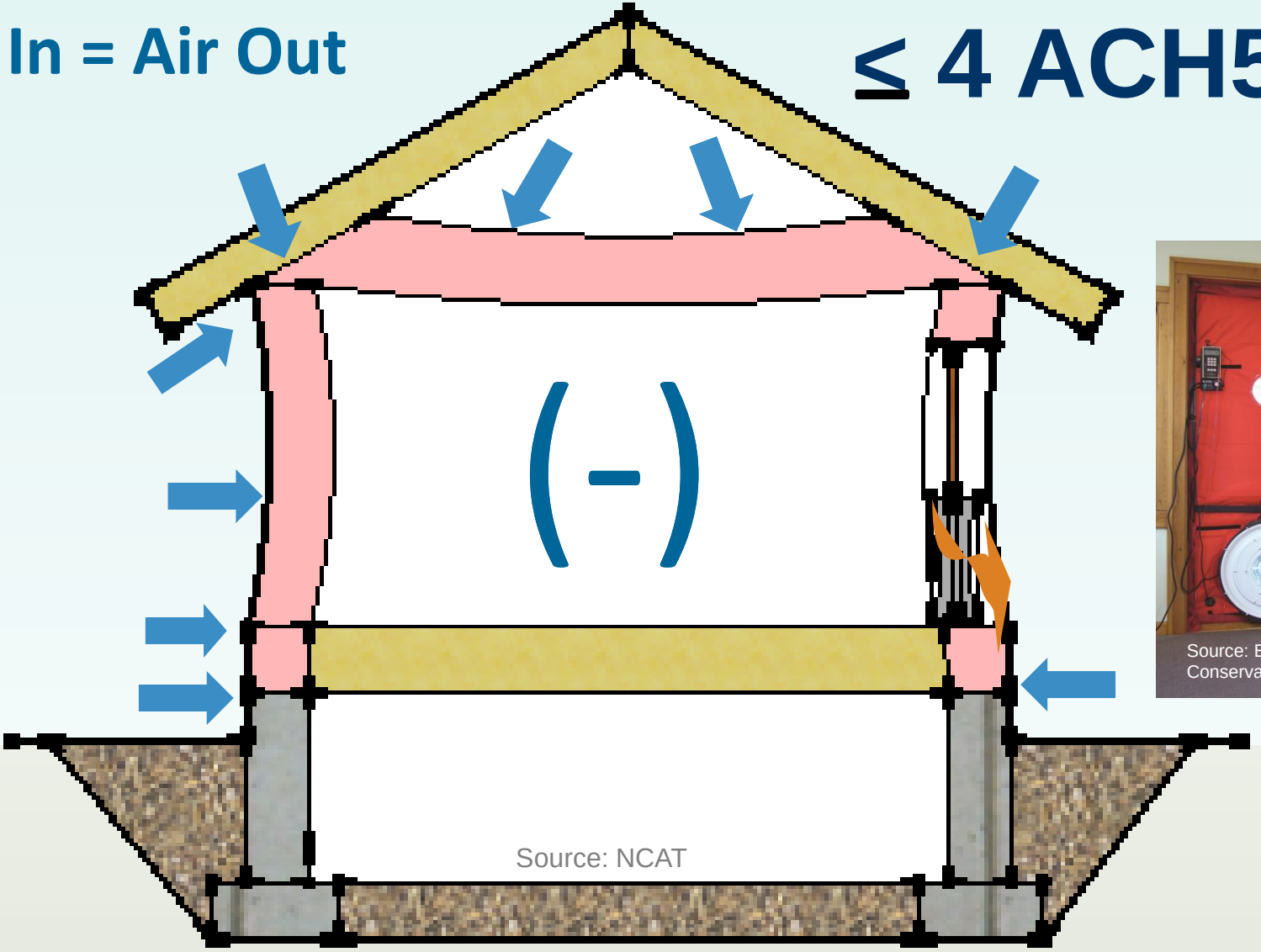
Source: ENERGY STAR New Homes

Depressurization Blower Door Test

R402.4.1.2

Air In = Air Out

≤ 4 ACH50



Source: NCAT

Source: Energy Conservatory

Applying Mastic

R403.2.2

Duct Tightness Testing

R403.2.2

Postconstruction Test

Total Leakage or Leakage to the Outside

<= 4 cfm/100 SF (at 25 PA)

Former leakage to outside limit was 8 cfm/100 SF

Former total leakage limit was 12 cfm/100 SF

Rough-in Test

Total Leakage

<= 4 cfm/100 SF (at 25 PA)

Former total leakage limit was 6 cfm/100 SF

Testing not required if ducts and air handler entirely within building thermal envelope.

Building Cavities as Return Ducts

R403.2.3

2012 IECC prohibits use of building cavities for either supply or return.

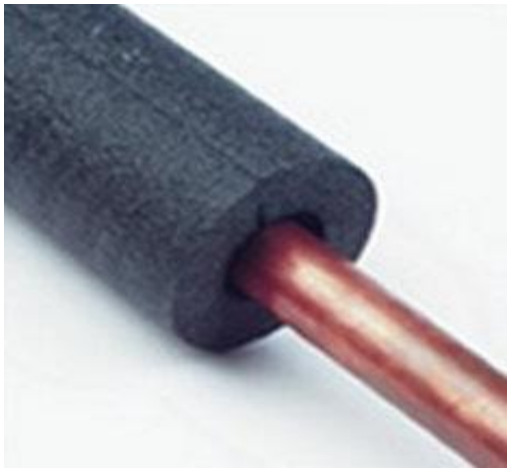
Montana amended to allow use of building cavities for return.

Source: USDOE Building Energy Codes University

Service Hot Water Systems

R403.4.2

R-3 Insulation on:



- Piping > ¾ in. nominal diameter
- Piping serving more than one dwelling unit
- ~~Piping from the water heater to kitchen outlets~~
- Piping located outside the conditioned space
- Piping from the water heater to a distribution manifold
- Piping under a floor slab
- Buried piping
- Supply and return piping in recirculating systems other than demand recirculation systems
- ~~Piping with run lengths > maximum run lengths for nominal pipe diameter in Table R403.4.2~~

~~All remaining piping to be at least R-3 or meet run length requirements in Table R403.4.2~~


Mechanical Ventilation
R403.5
“Build it tight and ventilate it right”

IRC R303.4 **Whole house mechanical ventilation mandatory when house is tighter than 5 ACH50.**

Mechanical Ventilation Fan Efficacy

R403.5.1

Whole-house mechanical ventilation system fans to meet efficacy in Table R403.5.1

Exception When fans are integral to tested and listed HVAC equipment, powered by electronically commutated motor

TABLE R403.5.1 MECHANICAL VENTILATION SYSTEM FAN EFFICACY			
FAN LOCATION	AIR FLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIR FLOW RATE MAXIMUM (CFM)
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

Continuous Mechanical Ventilation

IRC M1507.3.3

TABLE M1507.3.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

DWELLING UNIT FLOOR AREA (square feet)	NUMBER OF BEDROOMS				
	0-1	2-3	4-5	6-7	> 7
	Airflow in CFM				
< 1,500	30	45	60	75	90
1,501 - 3,000	45	60	75	90	105
3,001 - 4,500	60	75	90	105	120
4,501 - 6,000	75	90	105	120	135
6,001 - 7,500	90	105	120	135	150
> 7,500	105	120	135	150	165

Manual override required.

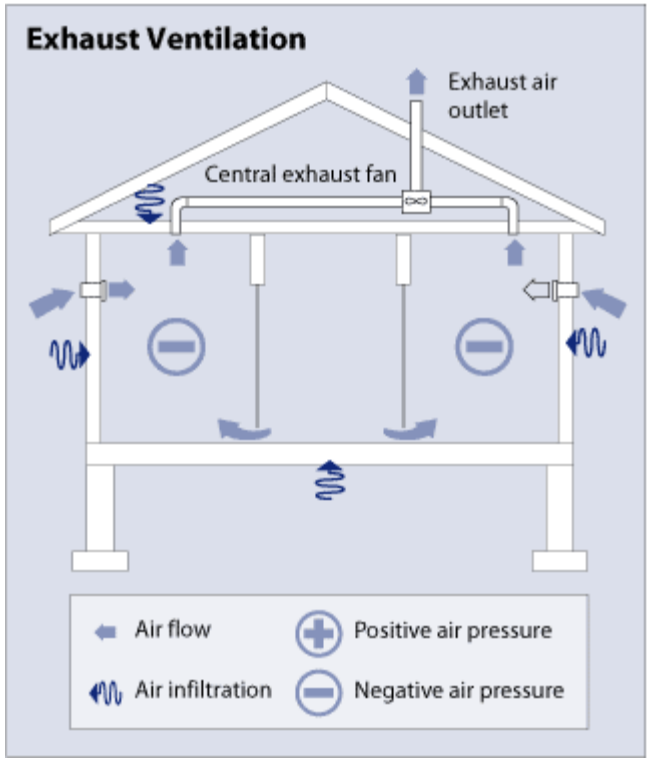
Intermittent Mechanical Ventilation

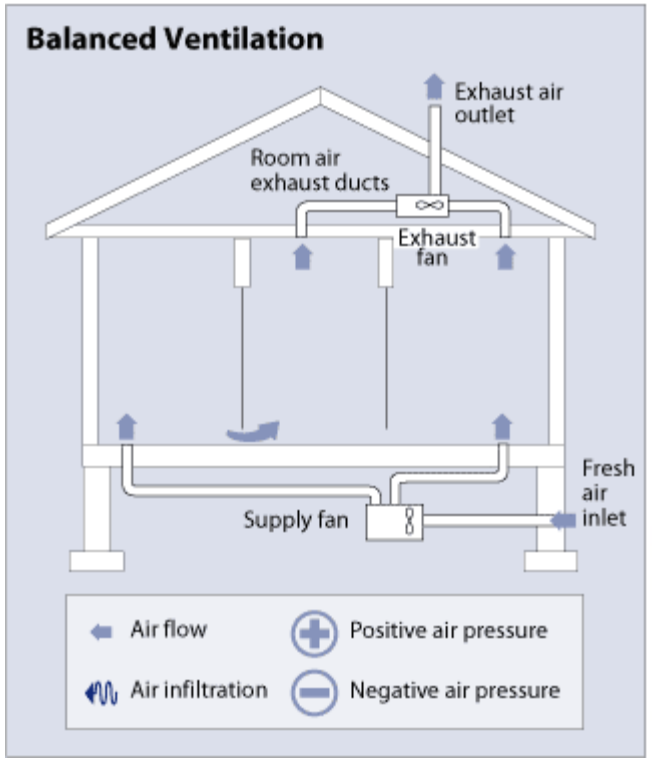
IRC M1507.3.3

TABLE M1507.3.3(2)

Intermittent Whole-House Mechanical Ventilation Rate Factors

Run-Time Percent in Each 4-Hour Segment	25%	33%	50%	66%	75%	100%
Factor	4	3	2	1.5	1.3	1.0





HOME VENTILATING INSTITUTE

Local Exhaust Ventilation (if installed)

IRC M1507.3.3

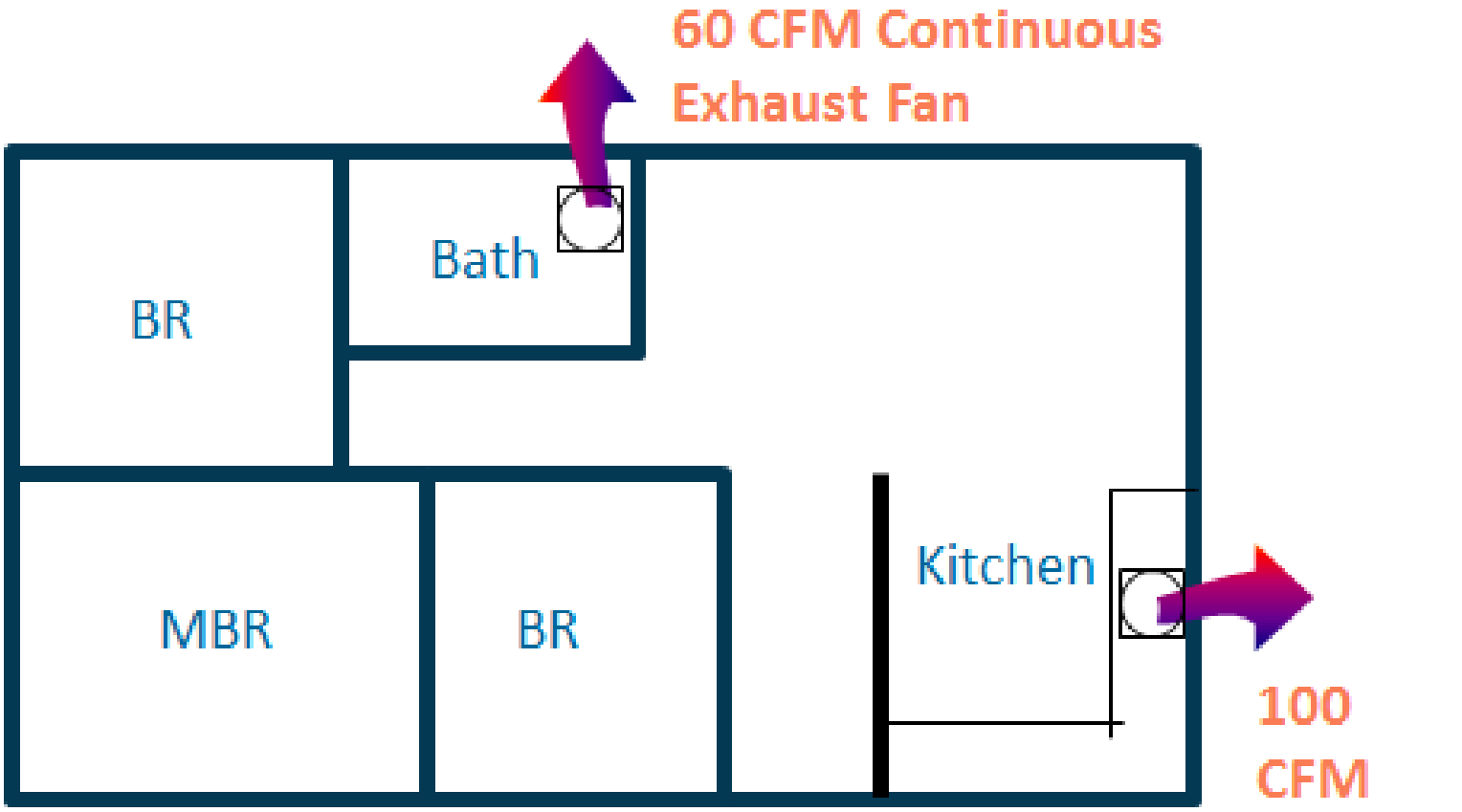
Table M1507.4
Minimum Rquired Local Exhaust Rates for One- and Two-Family Dwellings

Area to Be Exhausted	Exhaust Rates
Kitchens	100 cfm intermittent or 25 cfm continuous
Bathrooms-Toilet Rooms	Mechanical exhaust capacity of 50 cfm intermittent or 20 cfm continuous

Local Interpretation Question

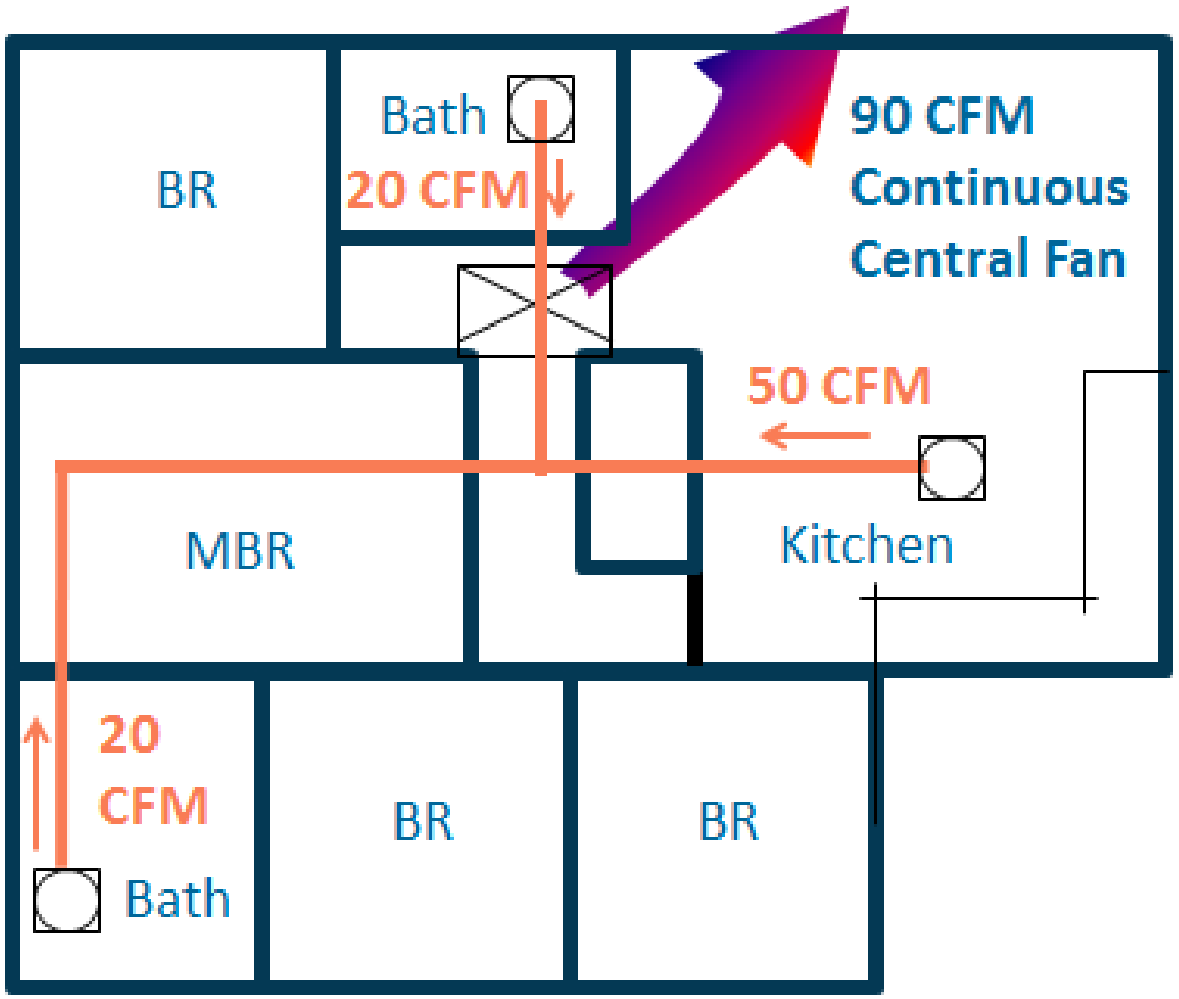
Does IRC R303.3 (Bathrooms may have 3ft^2 of glazing, ½ of which is openable or local exhaust per M1507) provide alternative to local mechanical ventilation if whole house ventilation is required?

Whole House Ventilation Example



3BR, 2000 SF House = 60 CFM

Whole House Ventilation Example



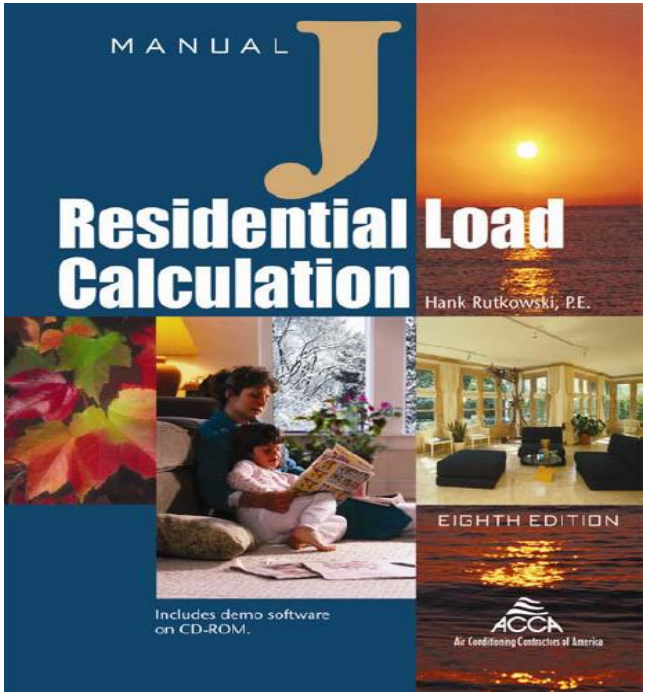
4BR, 3600 SF House = 90 CFM

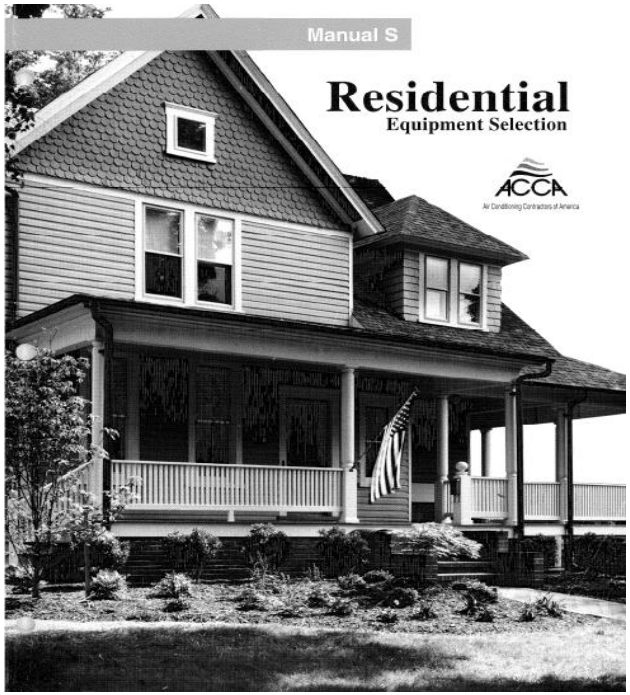
Equipment Sizing (Mandatory)

R403.6

Heating and Cooling Equipment

- Sized according to **ACCA Manual S**
- Based on loads calculated per **ACCA Manual J**
  (or other approved calculation methodology)





Effects of Oversizing Air-conditioning Equipment

Oversizing results in <u>short cycling</u>……

- Reduces equipment life
- Reduces efficiency
- Reduces filter effectiveness

Lighting (Mandatory)

R404.1

75% High Efficacy either:

1. **Lamps or**
2. **Permanently Installed Fixtures**

High Efficacy Lamps

1. Compact Fluorescent Lamps (CFL)
2. T-8 or small Diameter Linear Fluorescent Lamps
3. Lamps that meet the minimum lumens/watt

Low-wattage do not count.

Interior and exterior count.

Lighting (Mandatory)

R404.1

High Efficacy Lamp Values

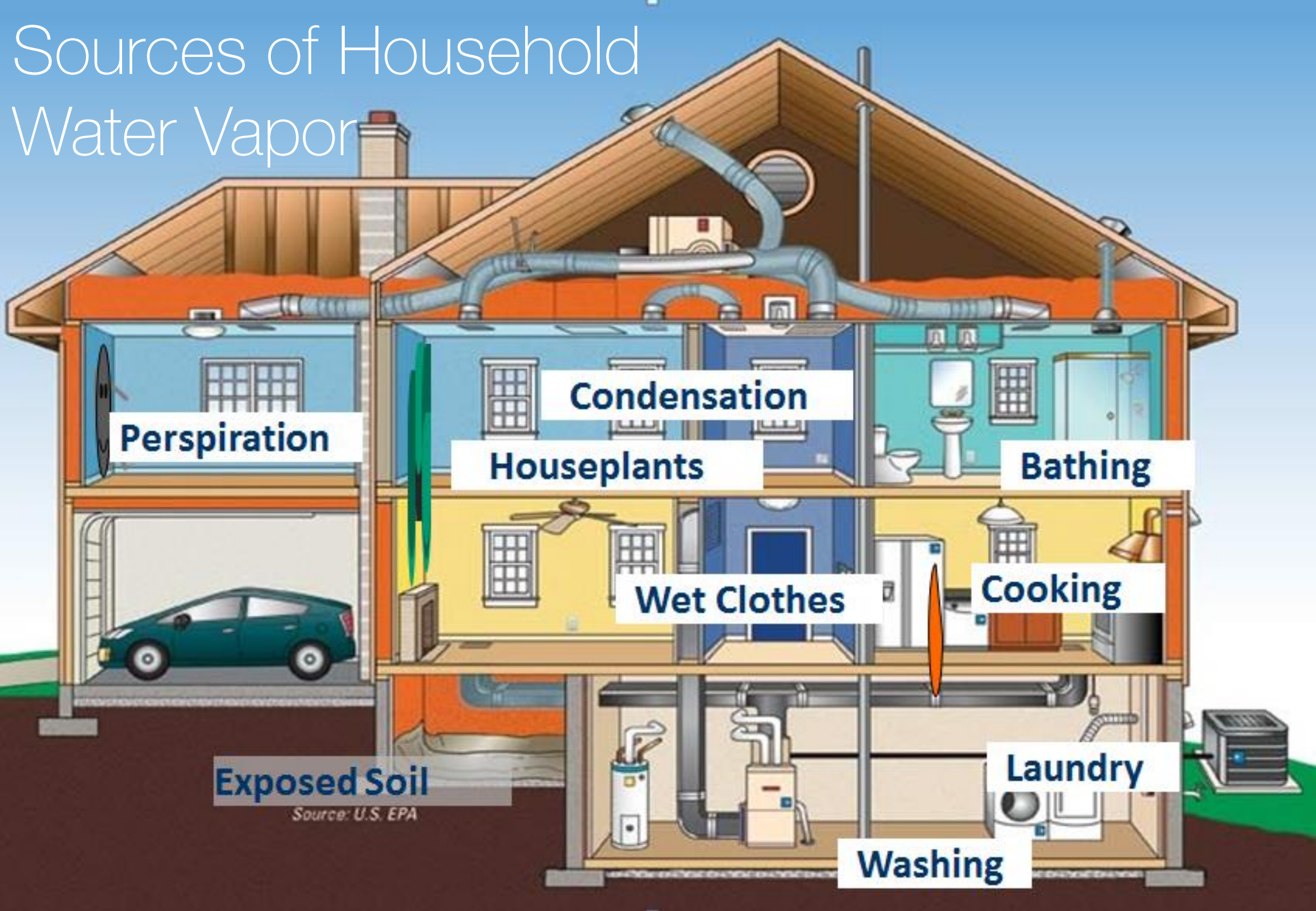
- 60 lumens per watt if over 40 W
- 50 lumens per watt if between 40 and 15 W
- 40 lumens per watt if 15 W less

Lamp Efficacy	
	Lum/Watt
Incandescent Tungsten Filament	7-18
Incandescent Tungsten Halogen	12-26
Linear Fluorescent	45-104
Compact Fluorescent	33-75
LED	70-140

Building Envelope Tightness

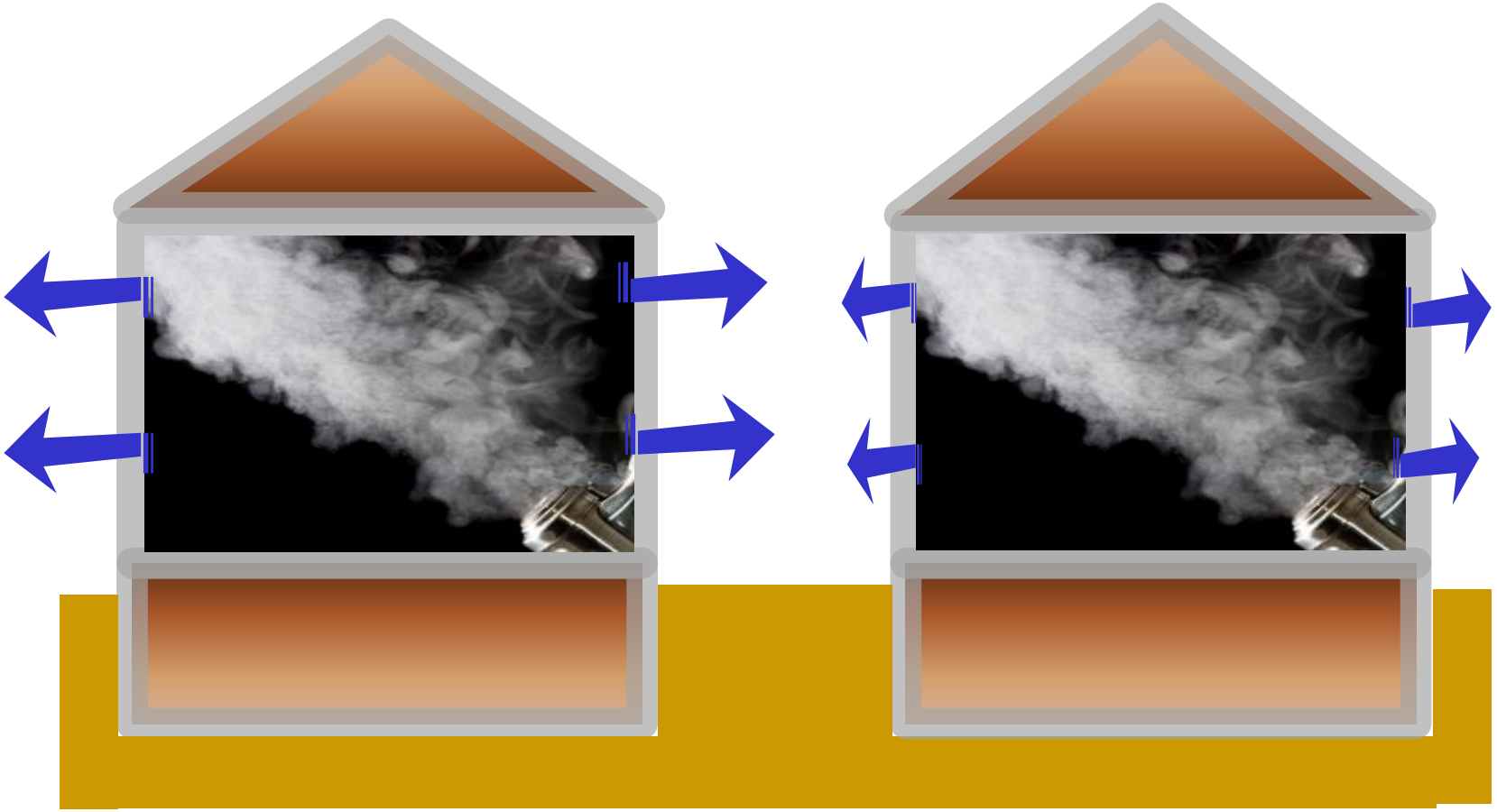
Air Barrier vs Vapor Retarder

Sources of Household Water Vapor

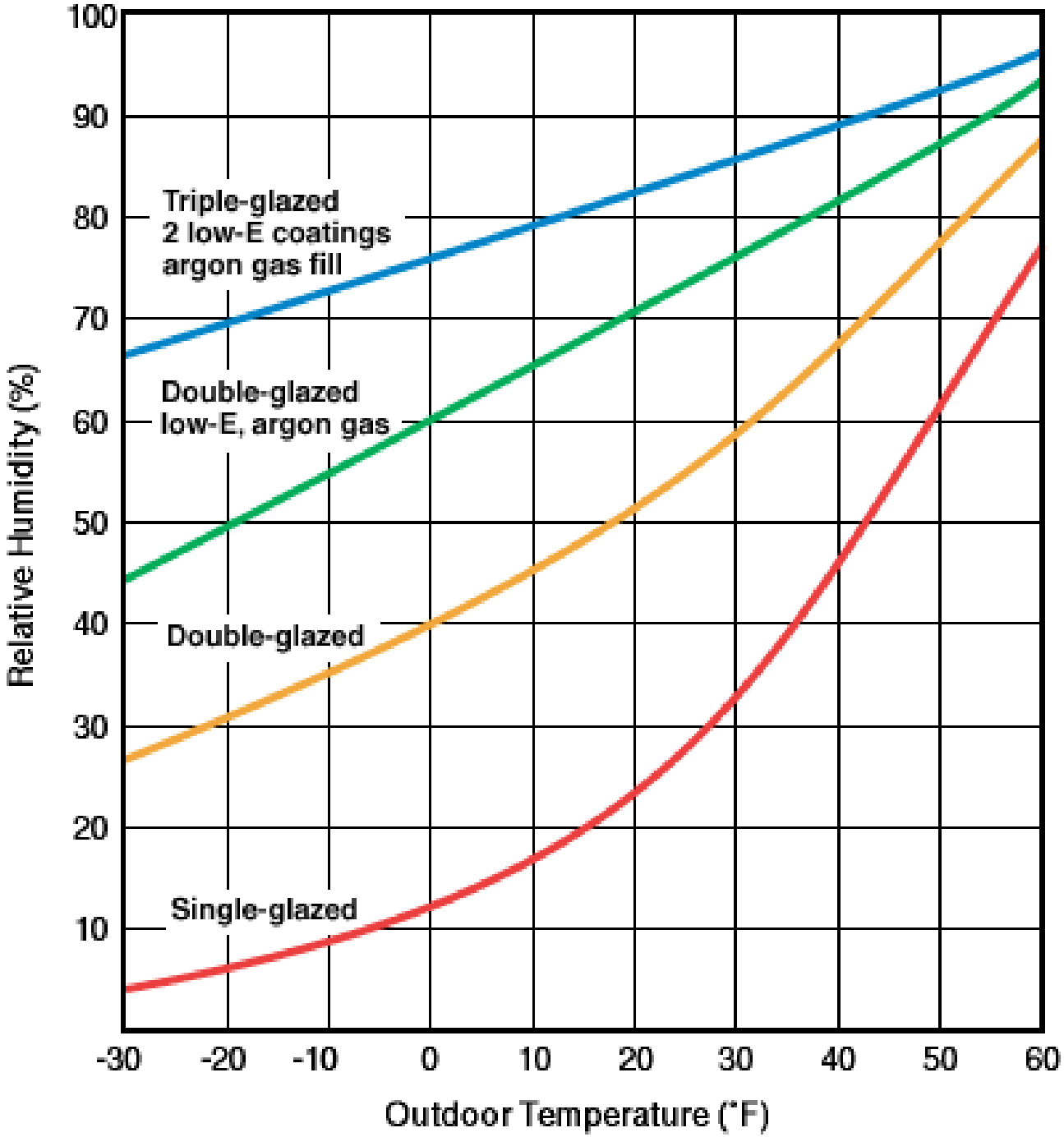


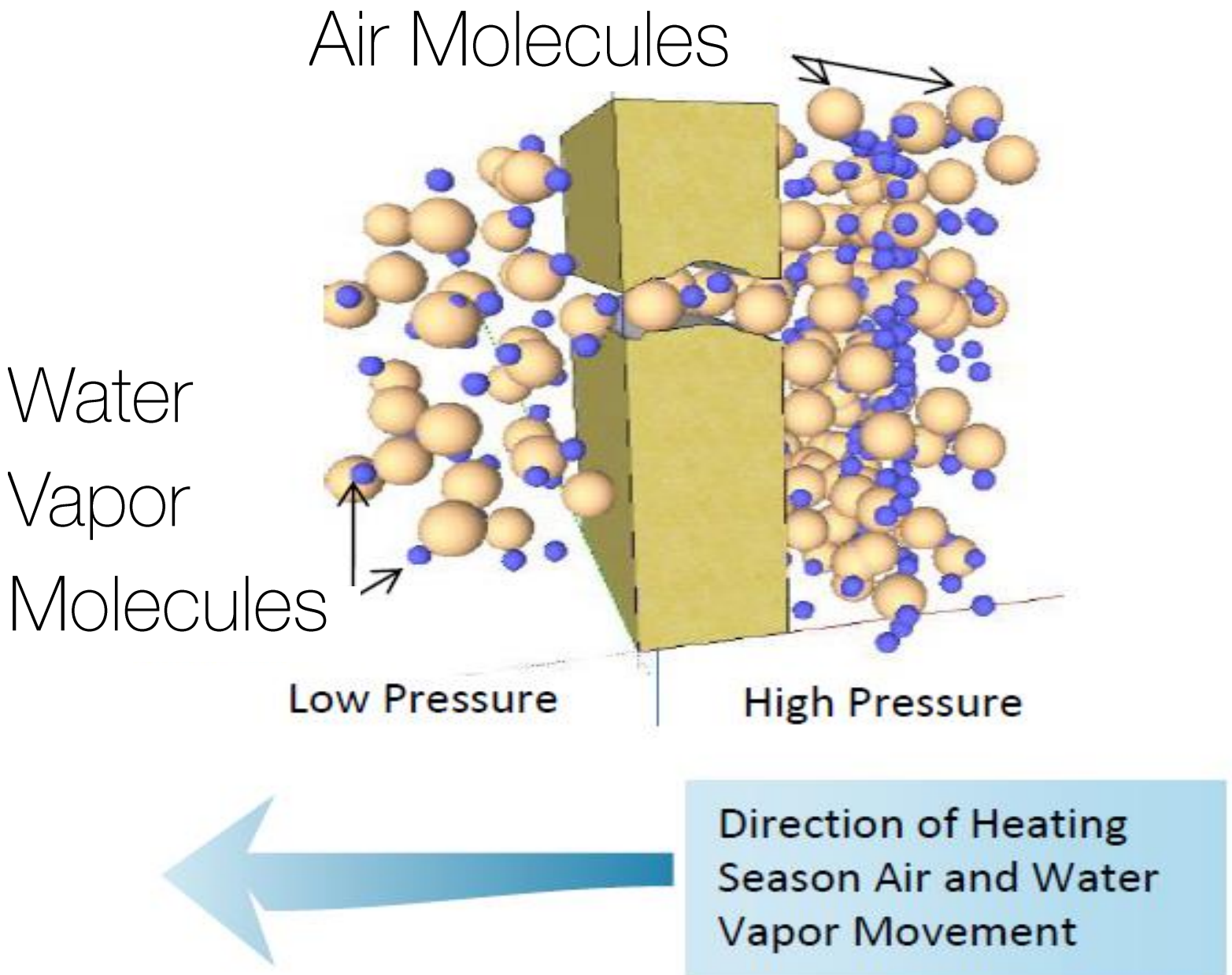
House Tightness and Interior Humidity

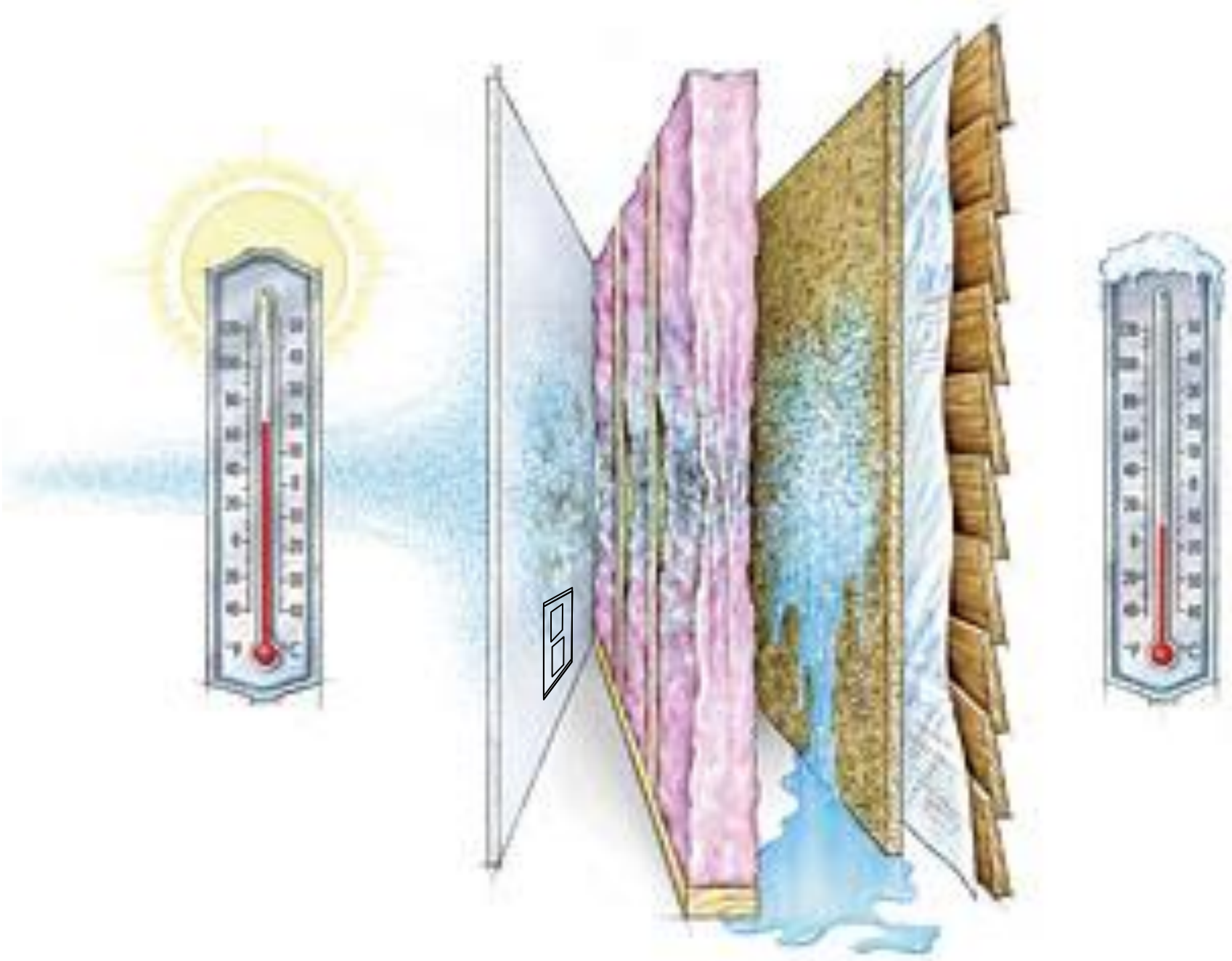
Tighter Building Envelope = Increased Interior Relative Humidity



Window Condensation Graph Source: Lawrence Berkeley National Laboratory

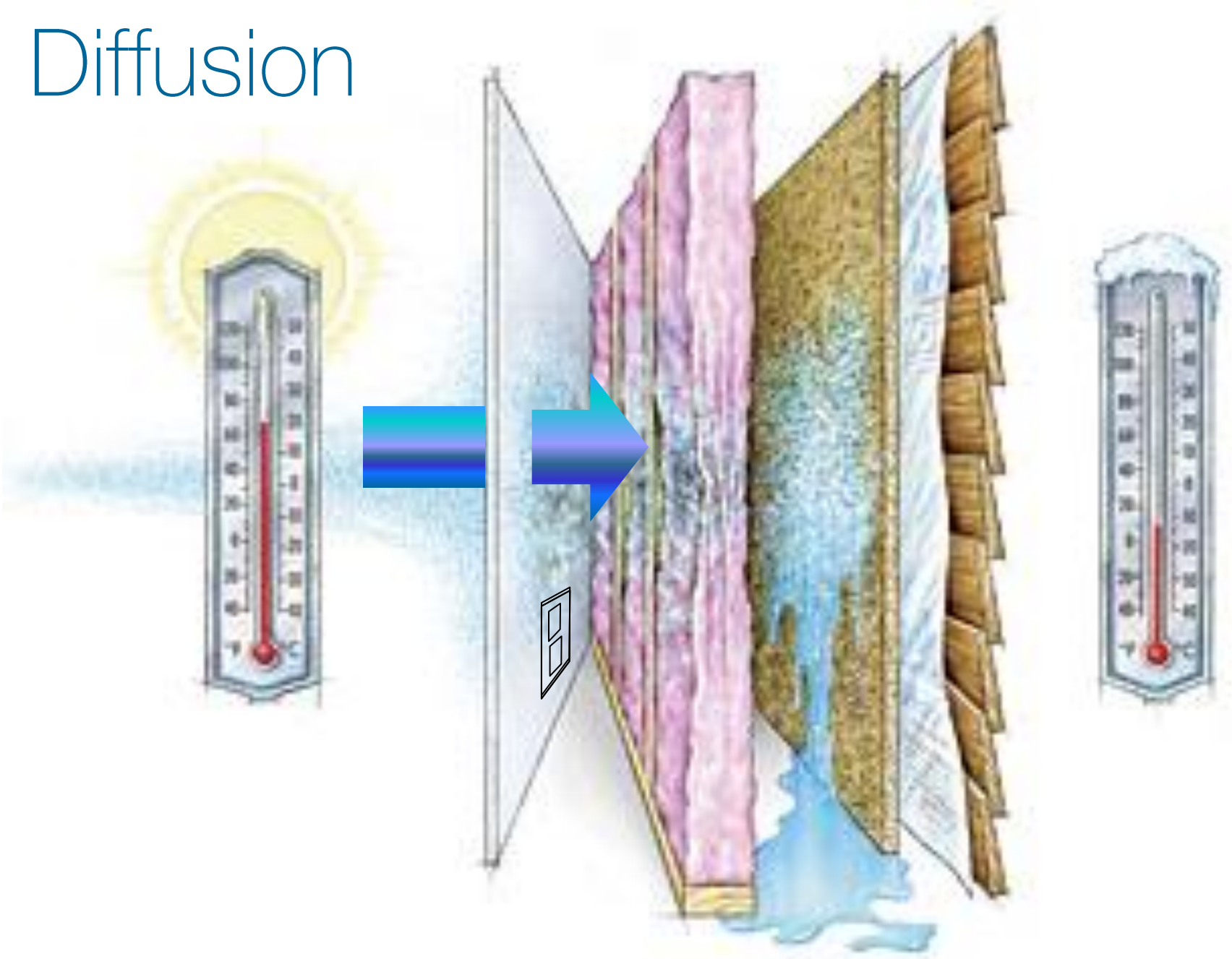



Air Molecules
Water Vapor Molecules
Low Pressure
High Pressure
Direction of Heating Season Air and Water Vapor Movement

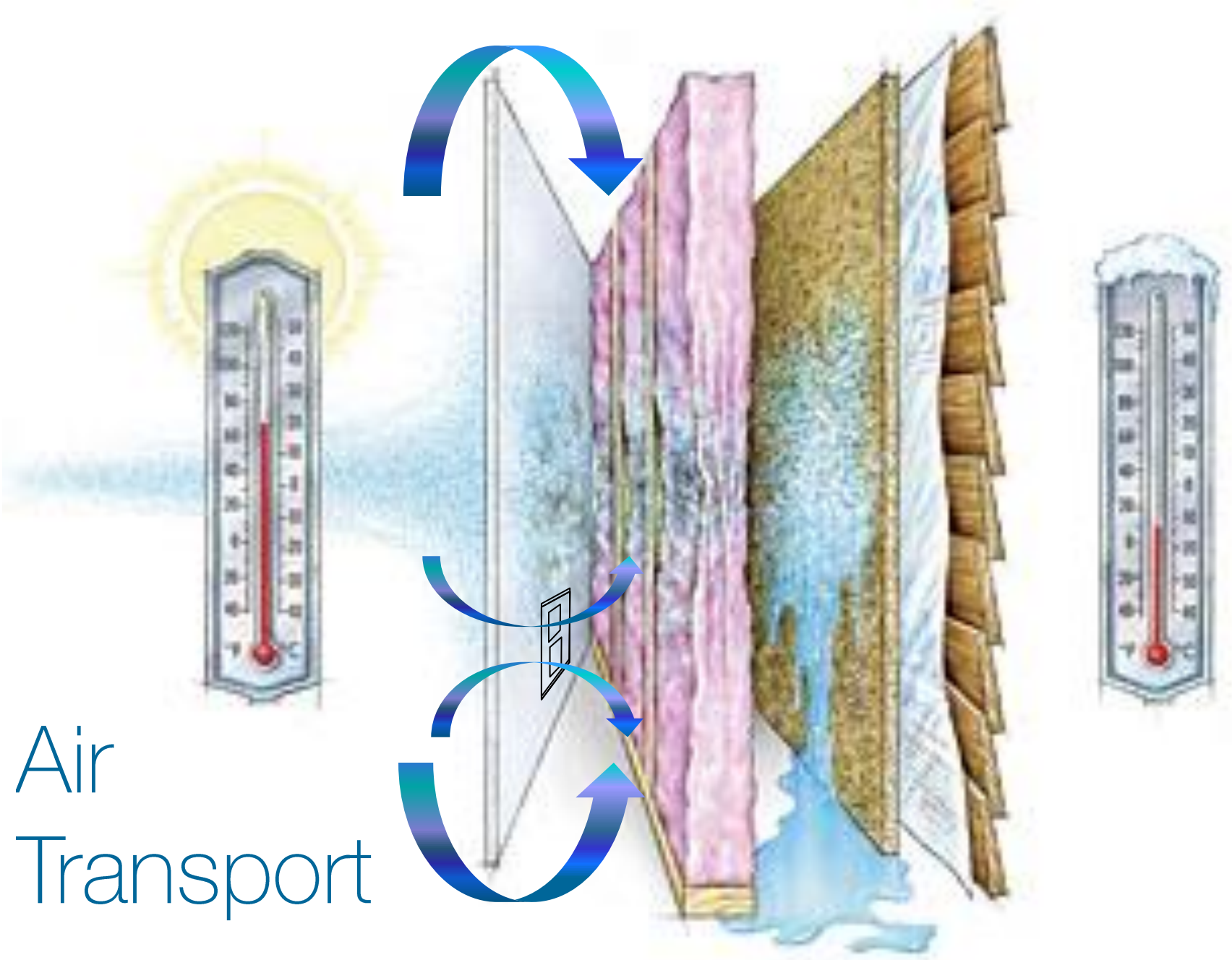


Courtesy of Building Science Corp.

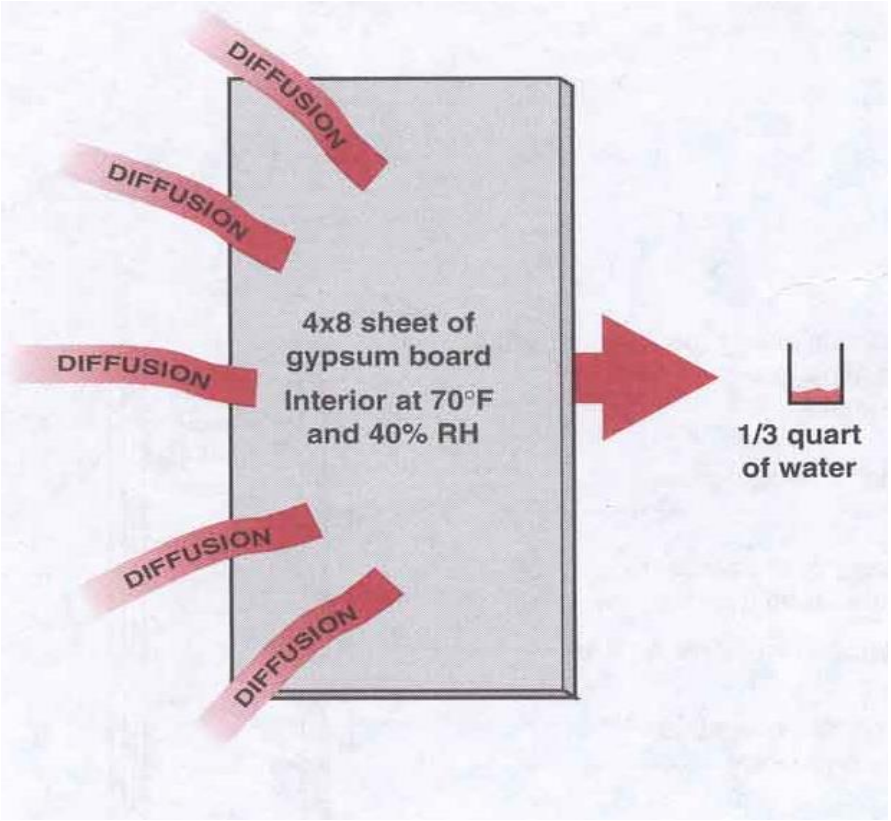
Diffusion

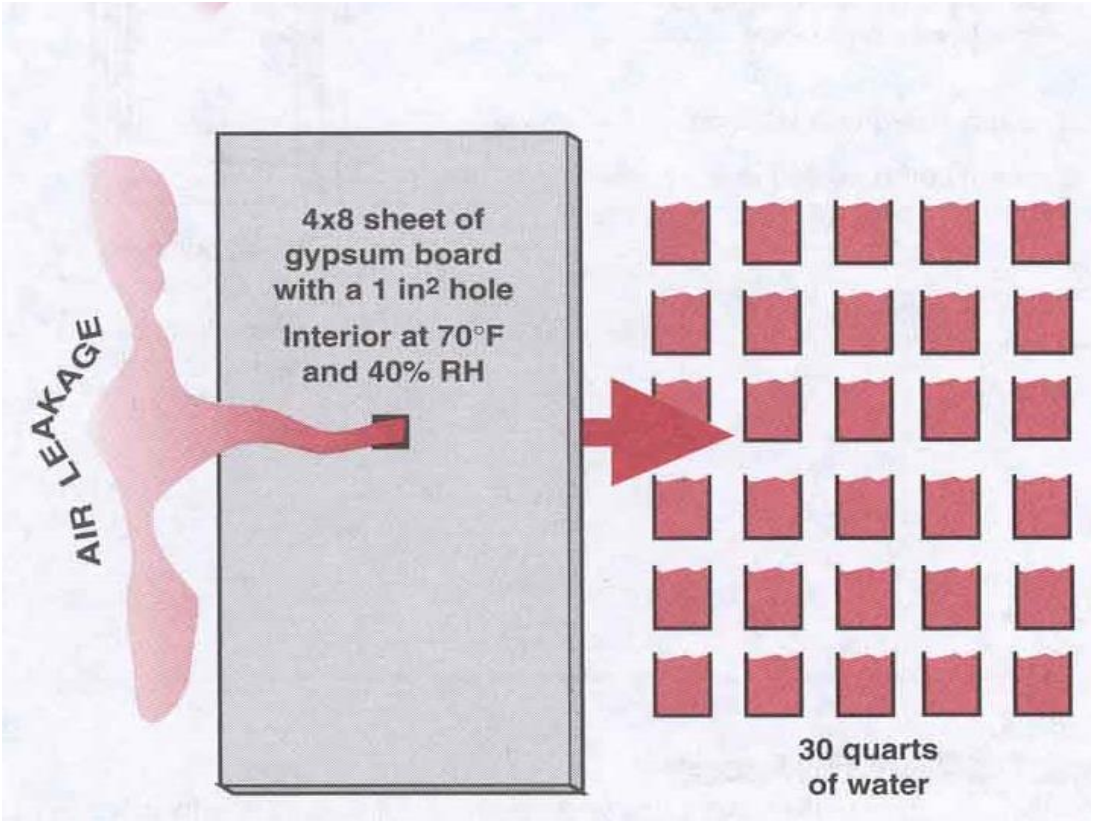


Air Transport



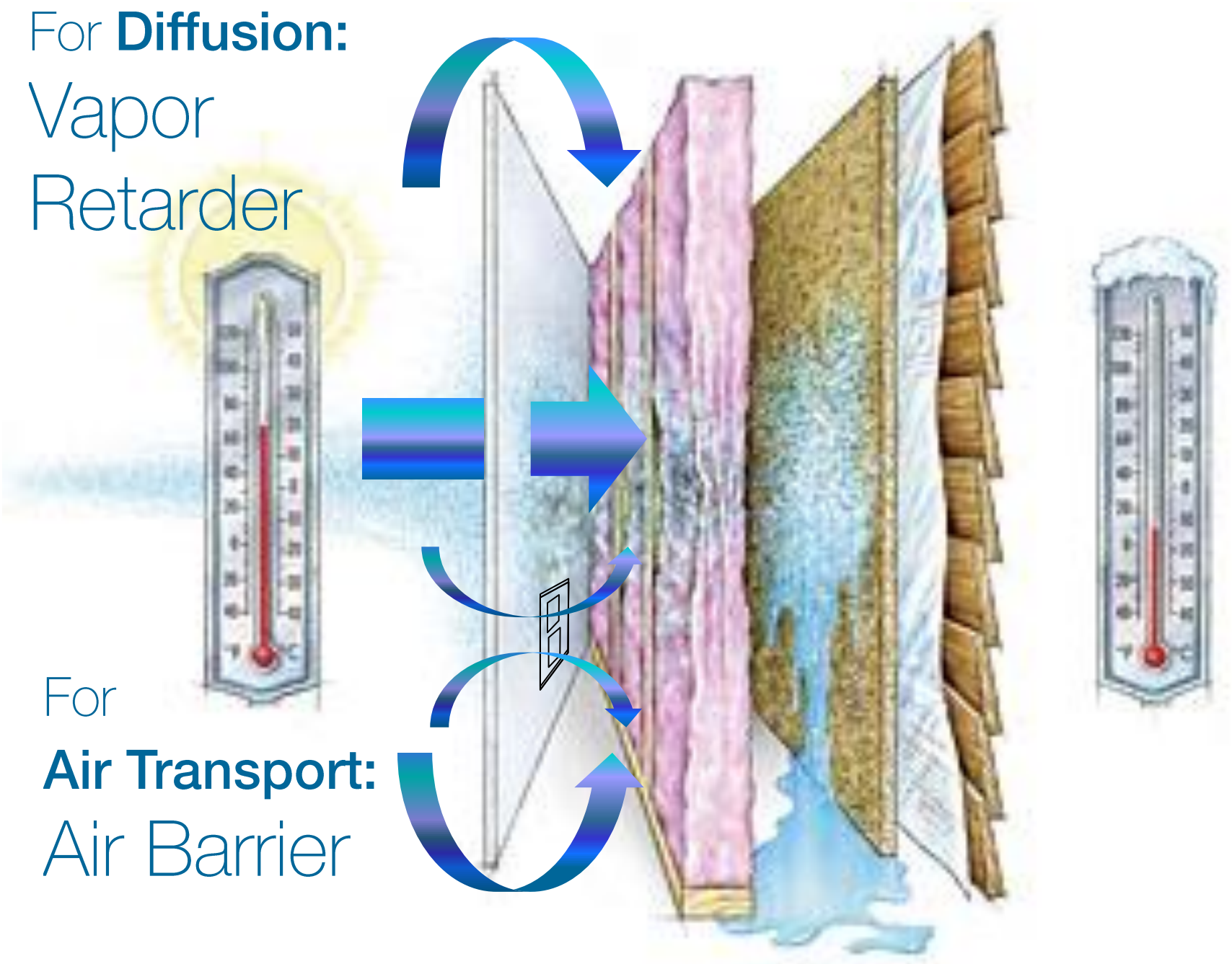
Vapor Diffusion vs. Air Transport





Source: USDOE Building Technologies Program, Whole-House Energy Savings in Cold and Very Cold Climates

For **Diffusion:**
Vapor
Retarder

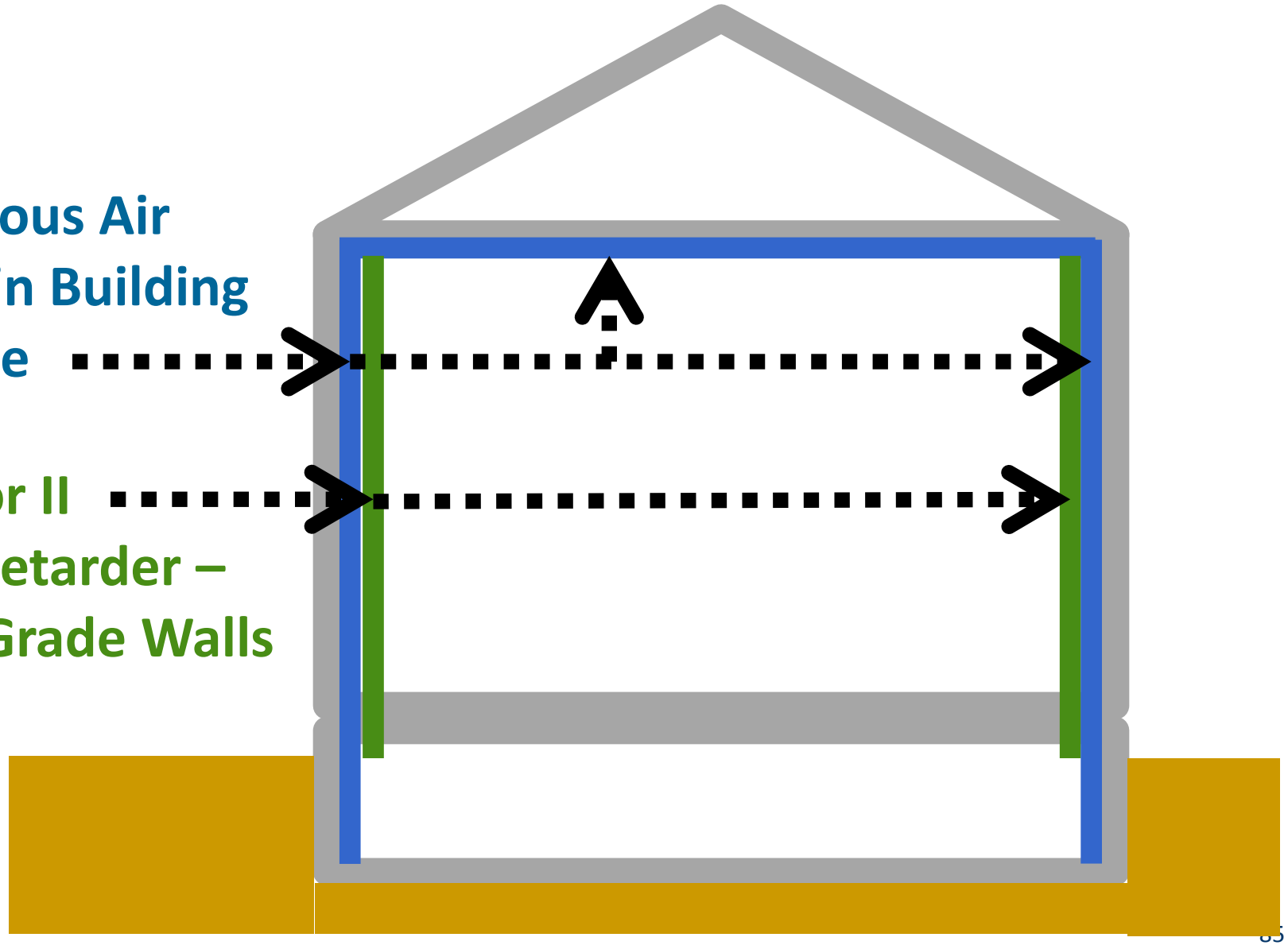


For
Air Transport:
Air Barrier

Vapor Retarder and Air Barrier Code Summary

Continuous Air Barrier in Building Envelope

Class I or II Vapor Retarder – Above Grade Walls



Vapor Retarders

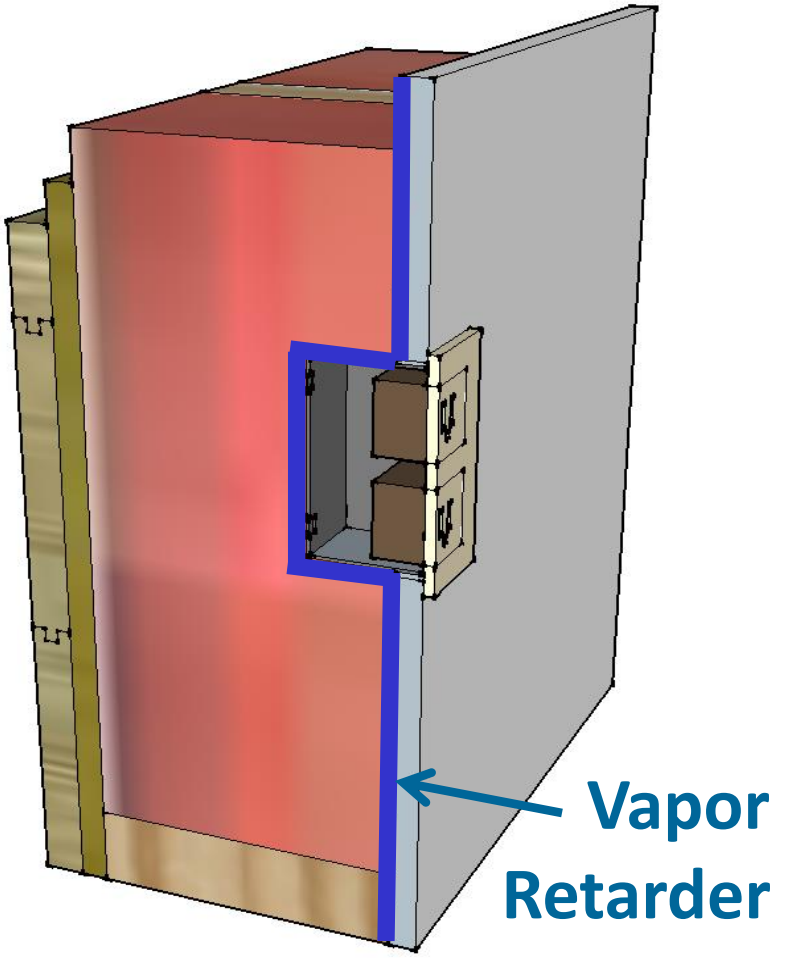
IRC R702.7

Class I or II vapor retarder at warm side of wall required.

Exception: Basement Walls and any portion of below grade walls.

Class III is allowed for:

- Vented cladding
- Continuous Insulation
  - R-7.5 for 2x4 wall
  - R11.25 for 2x6 wall



Source - **NCAT**

Vapor Retarders

IRC R702

Class	Definition	Examples
I	0.1 perm or less	Sheet polyethyl-ene, sheet metal, non-perforated aluminum foil
II	Greater than 0.1 perm to less than 1.0 perm	Kraft-faced fiberglass batts or low-perm paint
III	Greater than 1.0 perm to less than 10 perm	Latex or enamel paint

Impermeable (vapor barrier)

Semi-impermeable

Semi-permeable

Source: USDOE Building Technologies Program, Whole-House Energy Savings in Cold and Very Cold Climates

Class III Vapor Retarders Permitted in Cold Climate under Following Conditions

Zone	Class III vapor retarders permitted for:
6	• Vented cladding over fiberboard • Vented cladding over gypsum • Insulated sheathing with R-value ≥ R-7.5 over 2x4 wall • Insulated sheathing with R-value ≥ R-11.25 over 2x6 wall

Perm Ratings of Common Sheathing Materials

Plywood sheathing	More than 1.0 perm
OSB	More than 1.0 perm
Exterior gypsum	More than 1.0 perm
Fiberboard sheathing	More than 1.0 perm
Extruded polystyrene foam sheathing 1 inch	1.0 perm or less
Film-faced extruded polystyrene 0.5 inch thick with perforated facing	More than 1.0 perm
Nonperforeated foil-faced rigid insulation	Less than 0.1 perm
Polypropylene-faced rigid insulation	Less than 0.1 perm
Three-coat, hard-coat stucco over 2 layers of Type D asphalt-saturated Kraft paper and OSB	Less than 1.0 perm
Source: Lstiburek 2006. See Building Science Corporation 2006 for an extensive list of building material perm ratings.	

Hygroscopic Materials: Materials that absorb water, their vapor permeability goes up as the relative humidity goes up.

Hydrophobic Materials: Materials with permeance that does not change with relative humidity.

The **dry cup** is designed to simulate a heated dry building during a pouring rain, measuring the **drive into the building**. The water, or **wet, cup** measures the vapor drive moving out of the building.

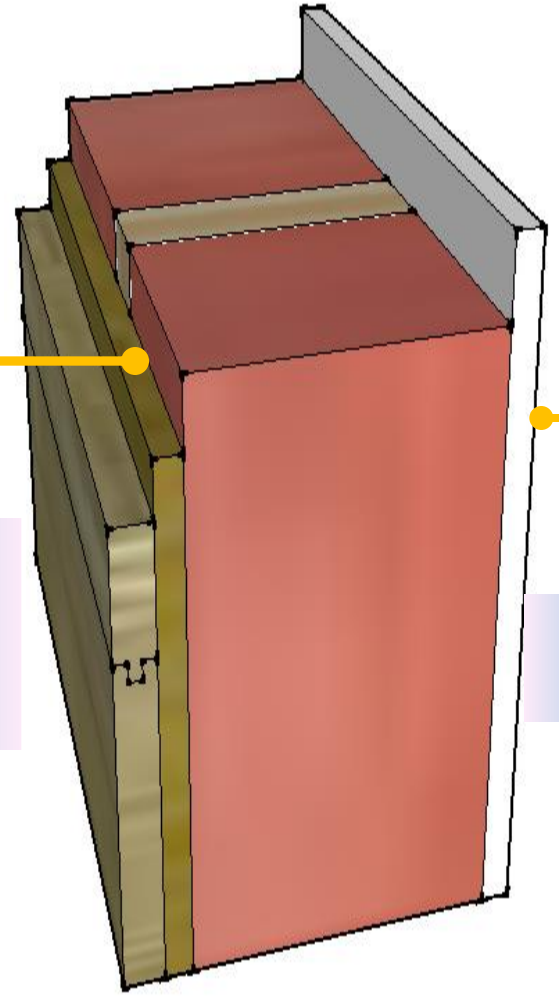
Source: USDOE Building Technologies Program, Whole-House Energy Savings in Cold and Very Cold Climates

Drying Potential - Cold Climate

Exterior
Cooler
Lower
Humidity

Interior
Warmer
Higher
Humidity

Semi-Permeable

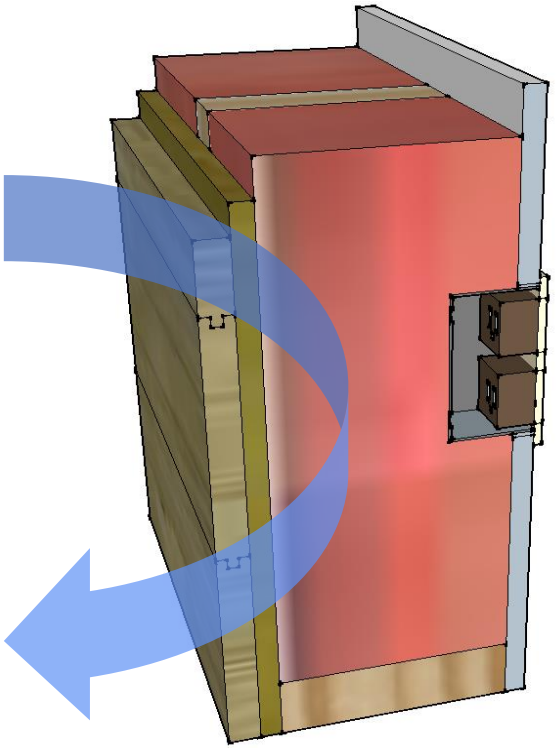


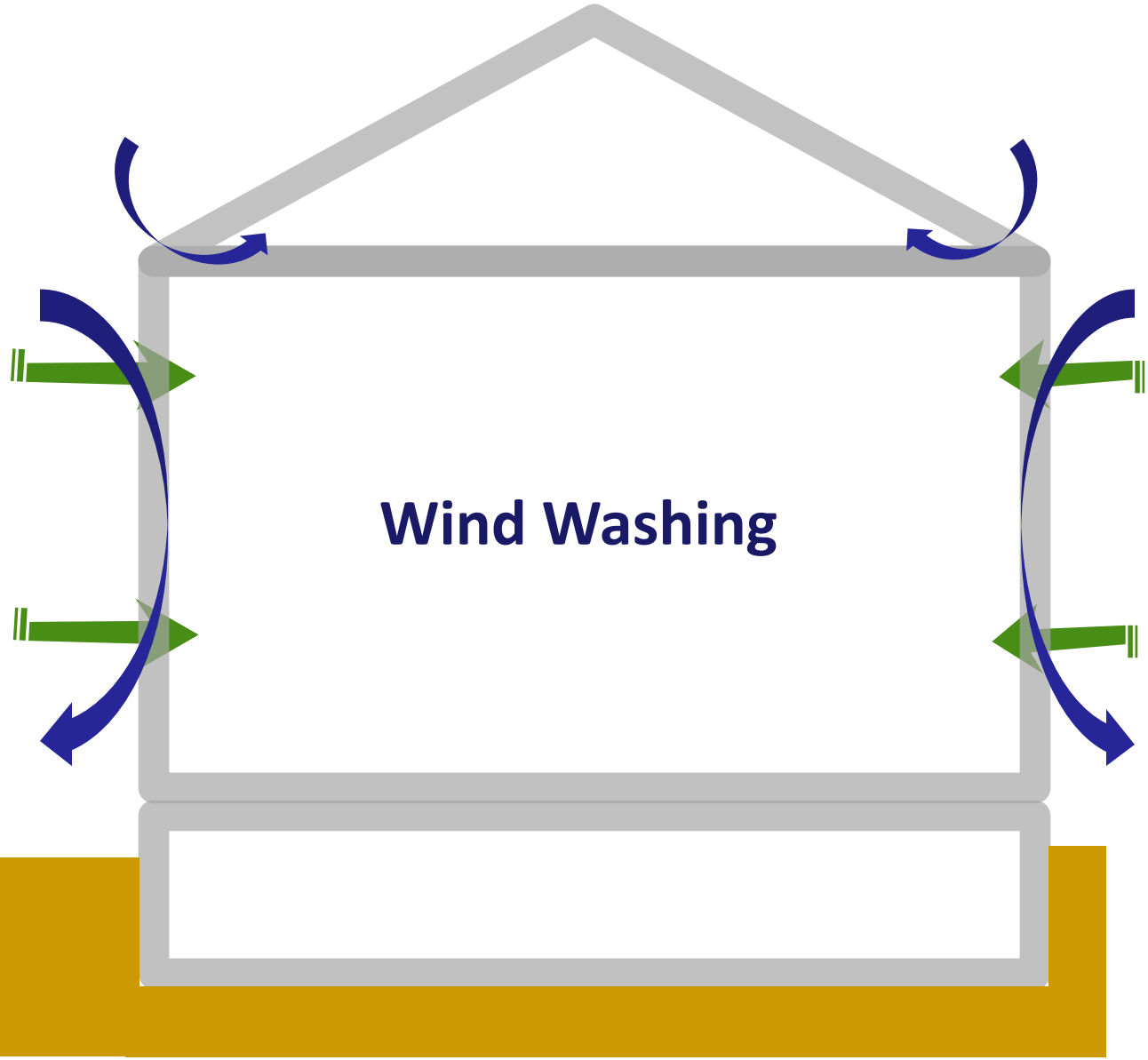
Vapor Retarder Layer Semi-Impermeable

Primary Drying to the Exterior

Secondary Drying to the Interior

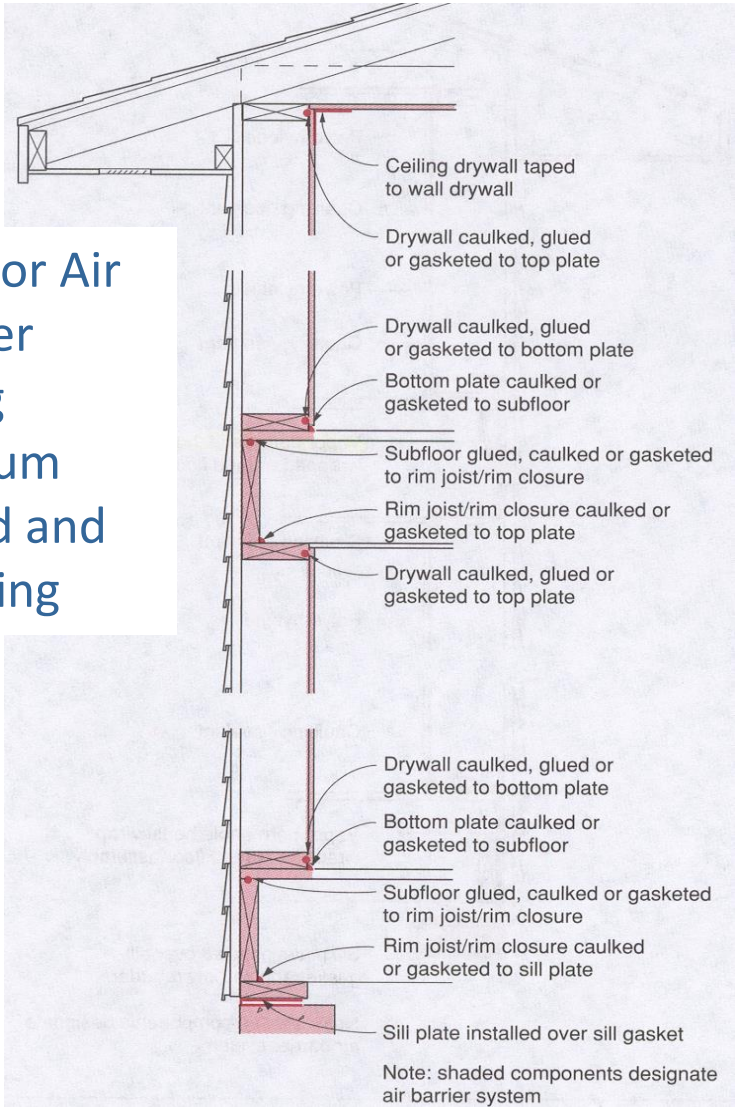
Envelope Control Challenges





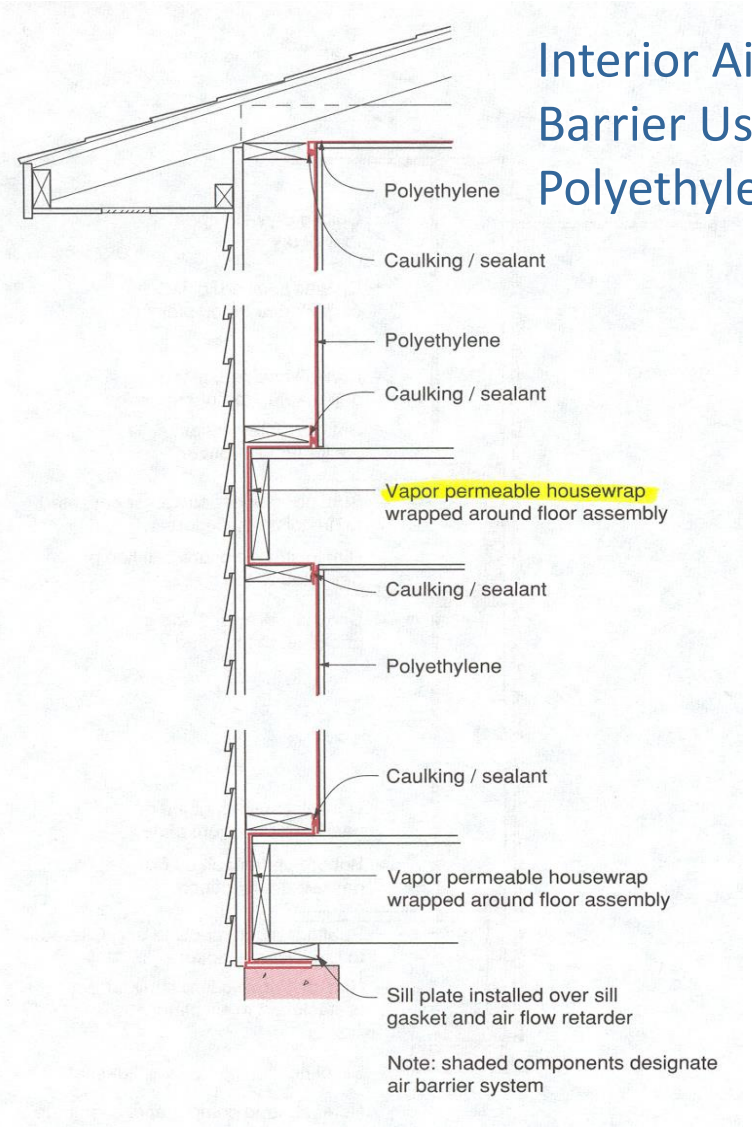
Interior Air Barrier Approaches

Interior Air Barrier Using Gypsum Board and Framing



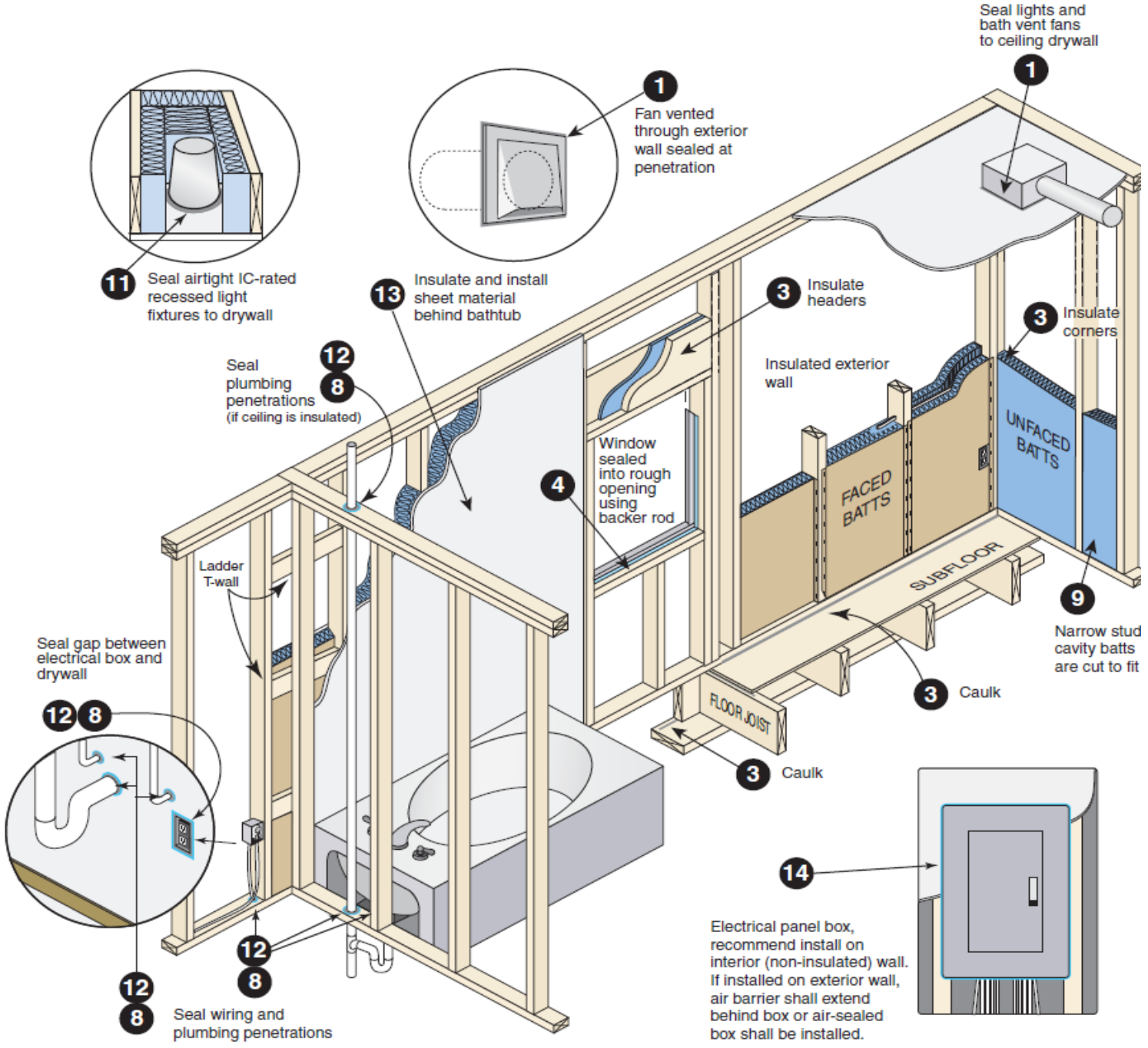
Source - Builder's Guide to CC

Interior Air Barrier Using Polyethylene



Source - Builder's Guide to CC

Appendix
2009 IECC



Why Insulated Sheathing?

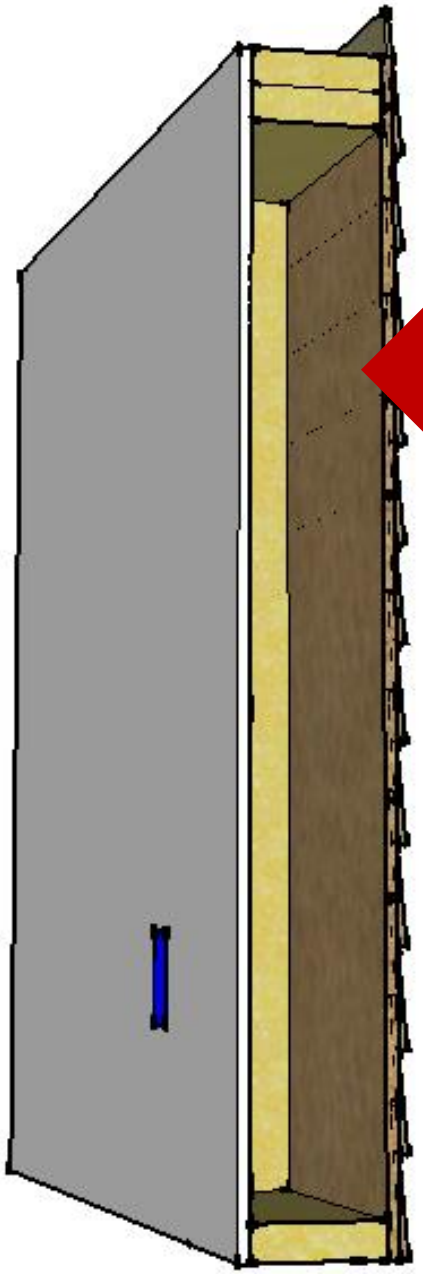
Exterior Insulated Sheathing = **Thermal Break + Insulation + Air Barrier**

Exterior Sheathing Temperature – No Insulation

Outside
30°F

Inside
70°F
45°F Dew Point

55°F Sheathing
Surface Temperature

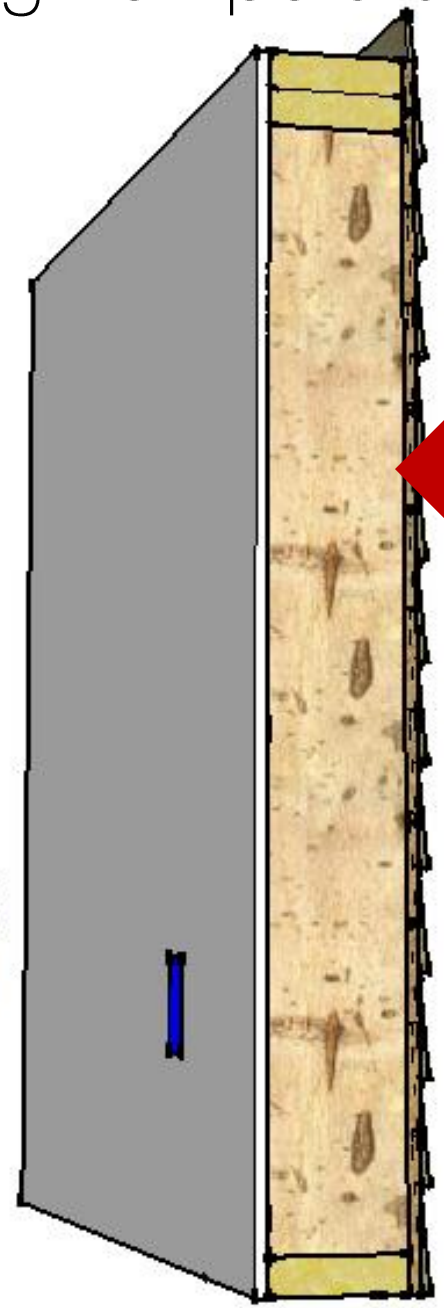


Exterior Sheathing Temperature – **With Insulation**

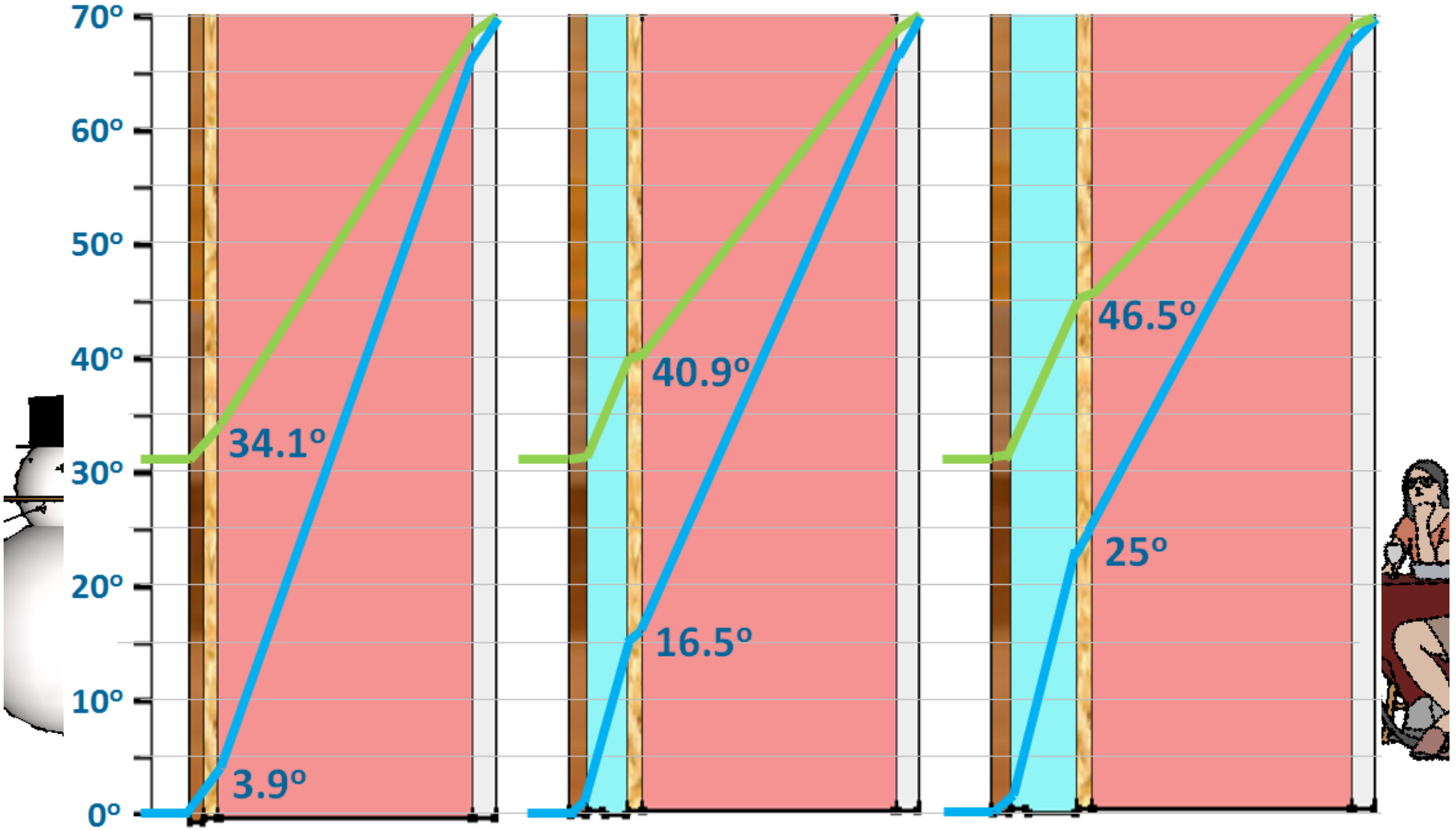
Outside
30°F

Inside
70°F
45°F Dew Point

34°F Sheathing
Surface Temperature



Nominal:	R19	R19 + R5	R19 + R10
Effective:	R14.4	R-19.4	R-23.8



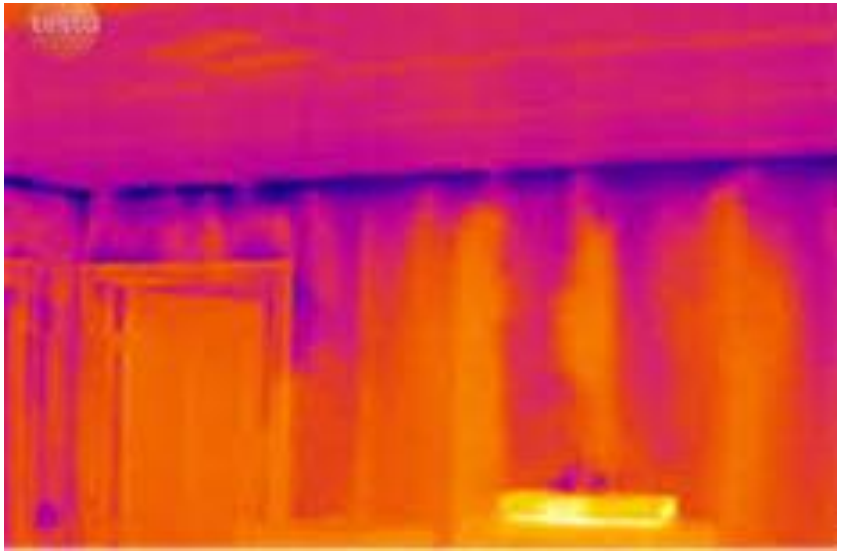

Defects No Longer Hidden
Performance Testing

Top Building Science Principles

"People do what you inspect, not what you expect."

Lou Gerstner, former CEO of RJR Nabisco and IBM

Source: Energy Conservatory



Source: Energy Conservatory

Corollary: "If you measure it, it gets better."

ENERGY STAR New Homes

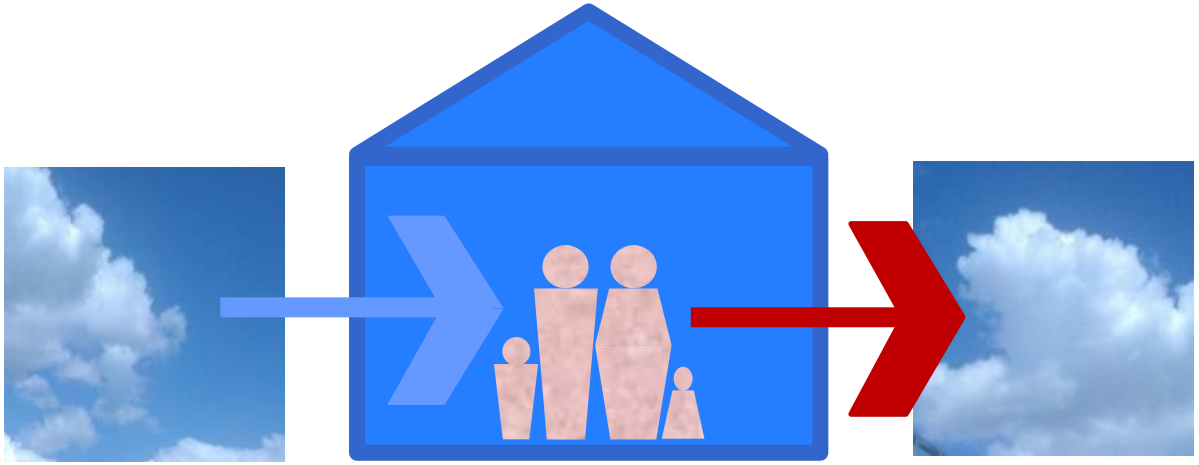
CHANGING WORLD:

BUILDER LIABILITY: NEW STORM

air leakage in envelope

air leakage in ducts

air leakage and air barriers in envelope



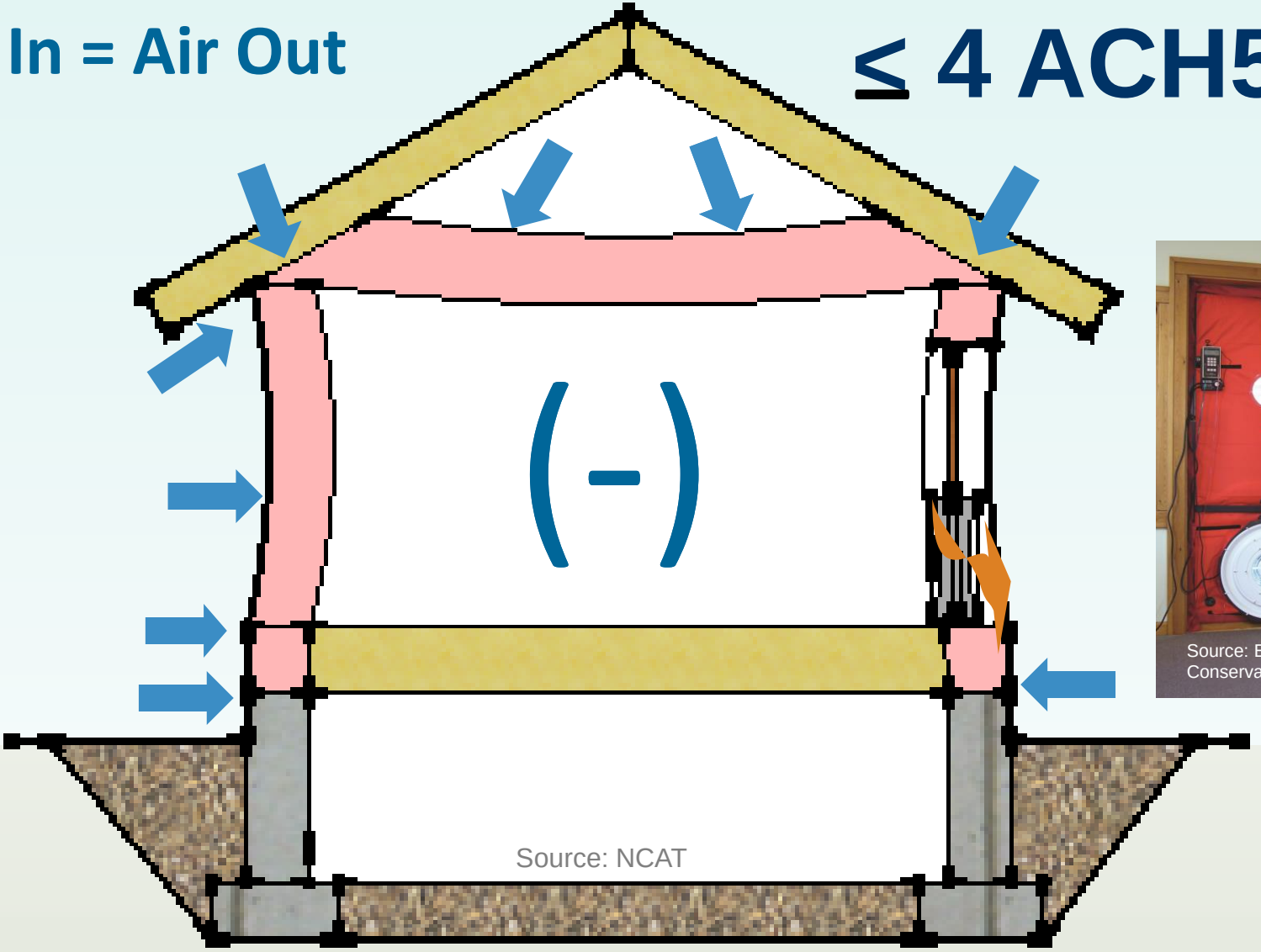
Air in = Air out

Depressurization Blower Door Test

R402.4.1.2

Air In = Air Out

≤ 4 ACH50

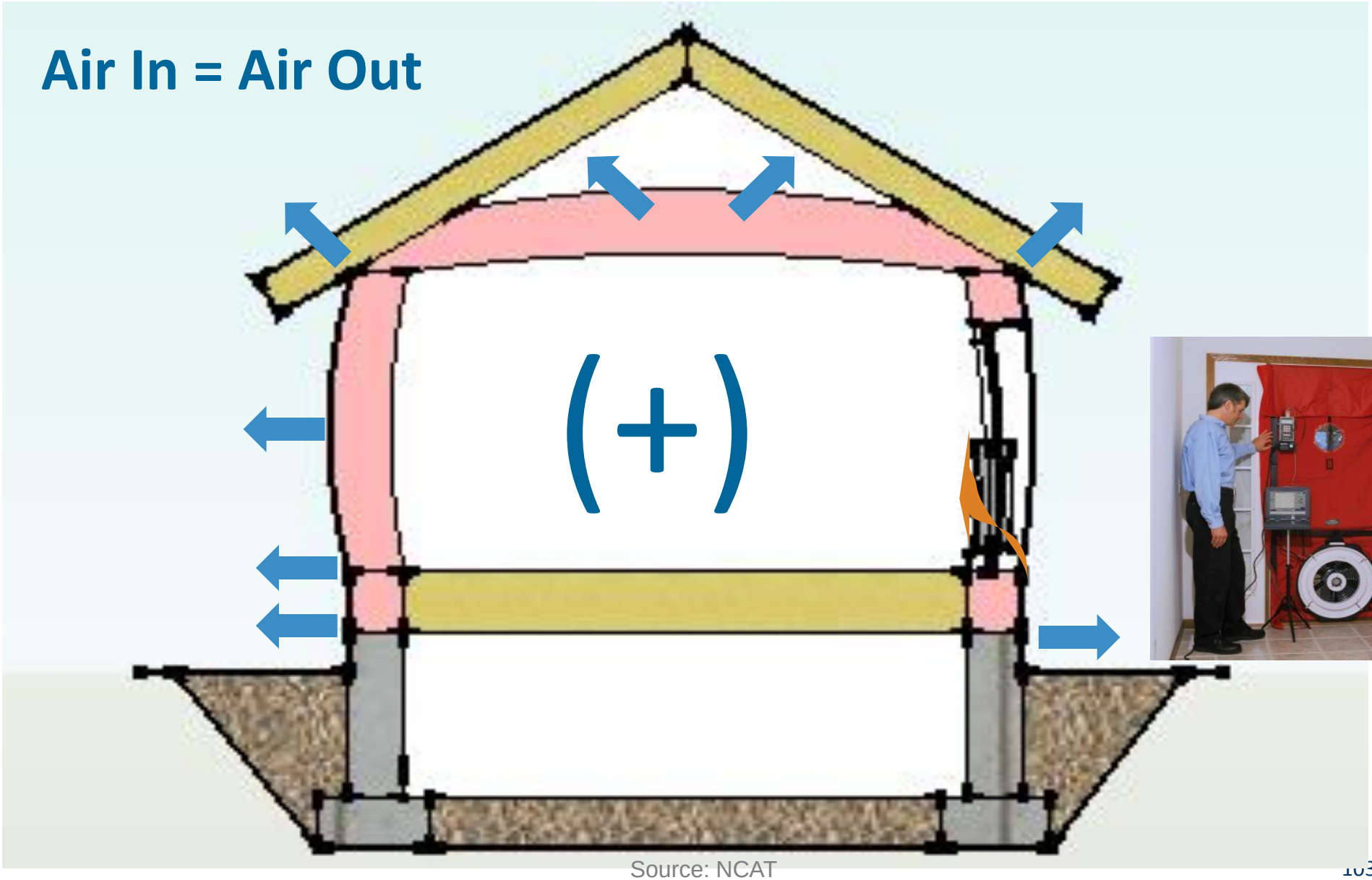


Source: NCAT

Source: Energy Conservatory

Pressurization Blower Door Test

R402.4.1.2



Source: NCAT

Blower Door Test
Depressurizing a House

BD3	A1
-50 Pa	1200 CFM
PR/ FL	1

STEPS

1. Install blower door with fan exhausting air from house. Rings must be to the inside of the house.

2. Connect hoses as shown.

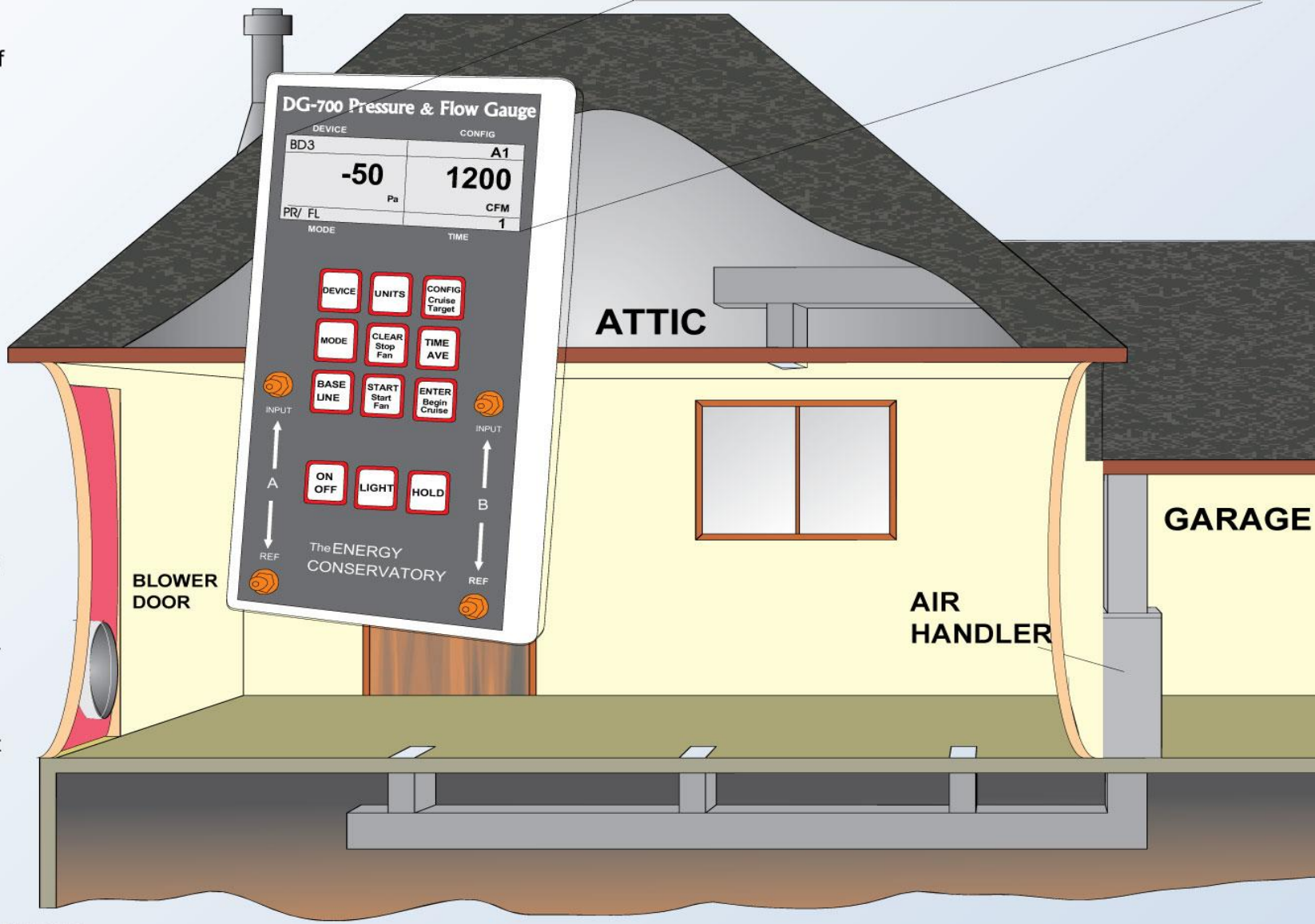
3. Manometer MODE should read PR/FL, CONFIG should reflect ring used (open, A, B, or C), and DEVICE should reflect BD3.

4. Open all interior doors. Close all exterior doors and windows.

5. Turn OFF airhandler, dryer, all fans and combustion equipment.

6. Turn on blower door, depressurize house to -50 Pascals (side A reading), +/- 0.5 Pa. (hint: canvas should be bulging inward). Use the smallest ring possible to get to -50 Pa. If you have to change the ring, be sure to reflect that in the manometer CONFIG setting.

7. Record reading on side B. This is your house cfm leakage at 50 Pa.



Blower Door Math

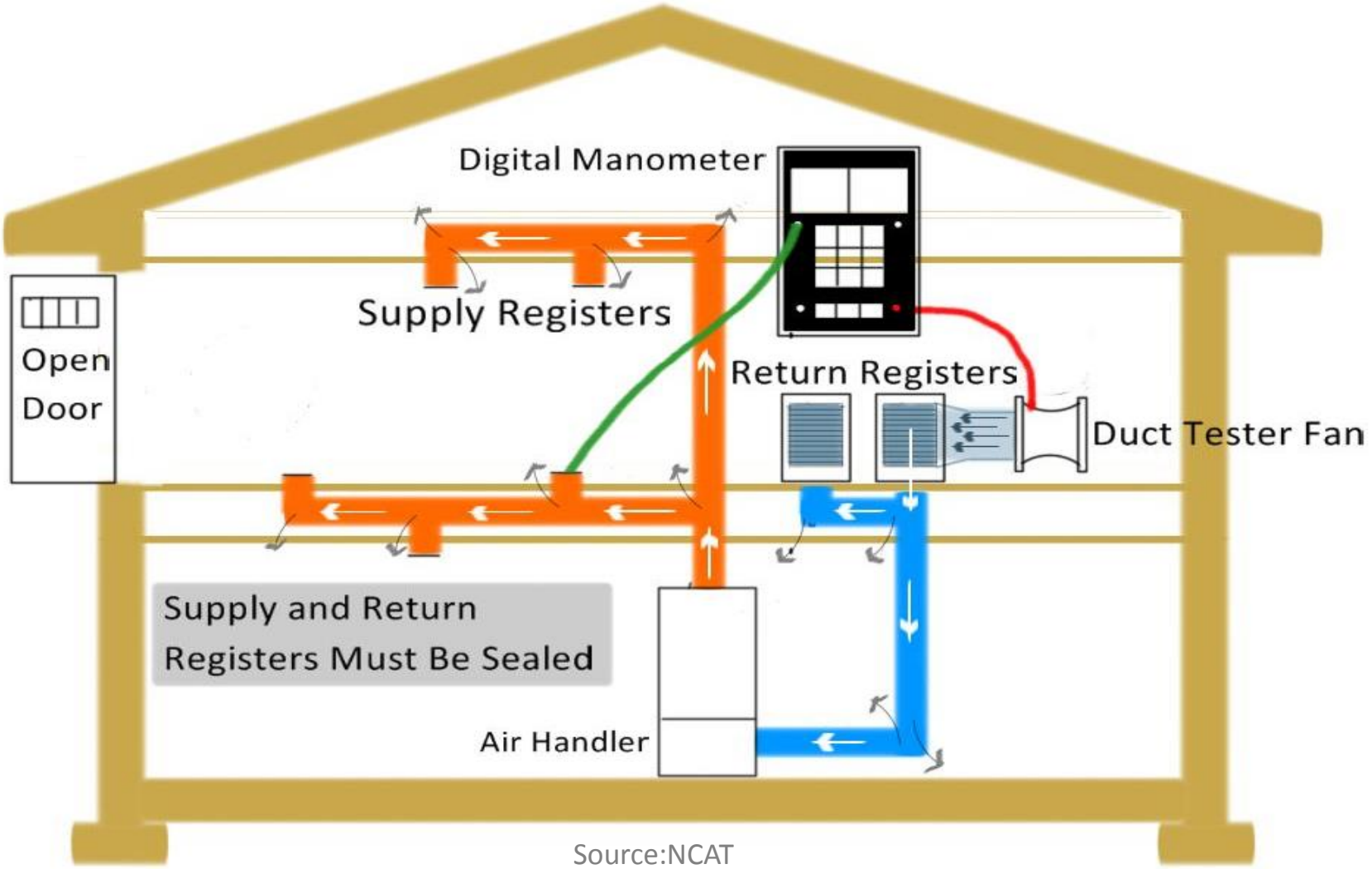
To calculate air changes per hour at 50 Pa:

$$ACH_{50} = \frac{CFM_{50} \times 60}{\text{House Volume}}$$

The volume is cubic feet enclosed by the conditioned space boundary.

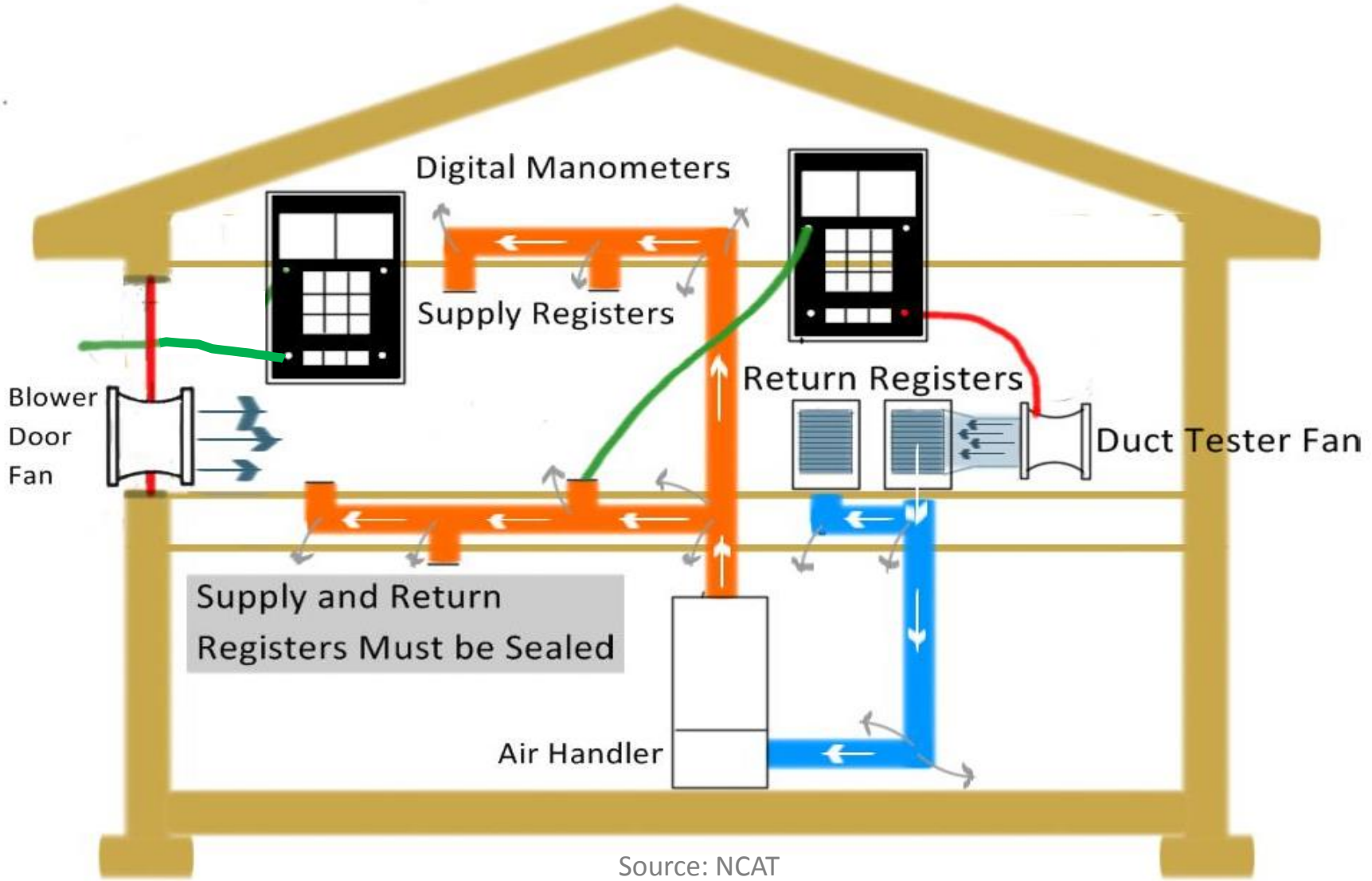
Duct Tightness Testing

Total Duct Leakage Test



Source:NCAT

Duct Leakage to the Outside



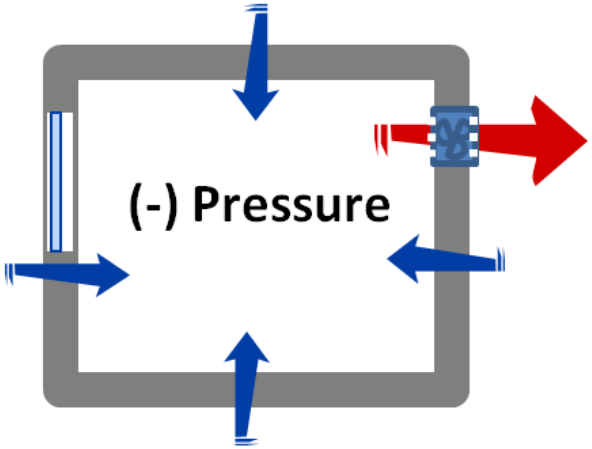
Source: NCAT

Ventilation – The Challenge

- Does it meet code?
- Is it effective?
- Is it energy efficient?

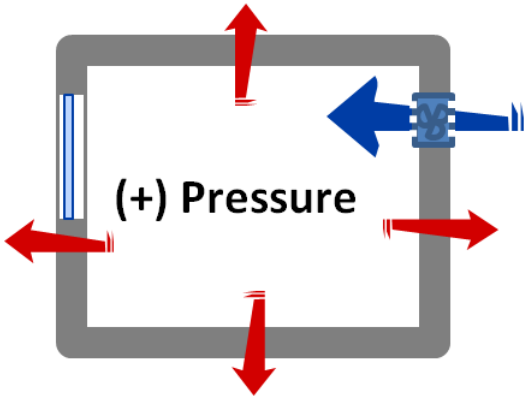
Mechanical Ventilation Strategies

Exhaust Only Mechanical Ventilation

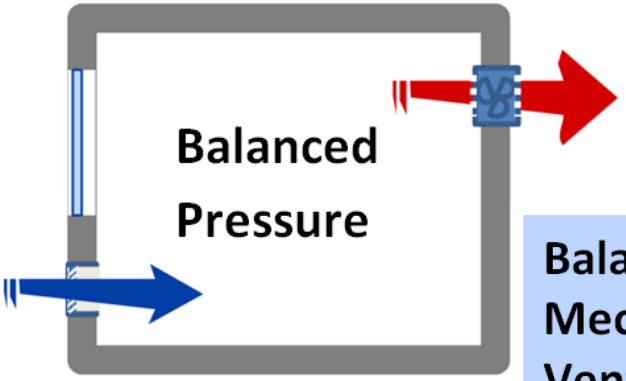


Supply Only Mechanical Ventilation

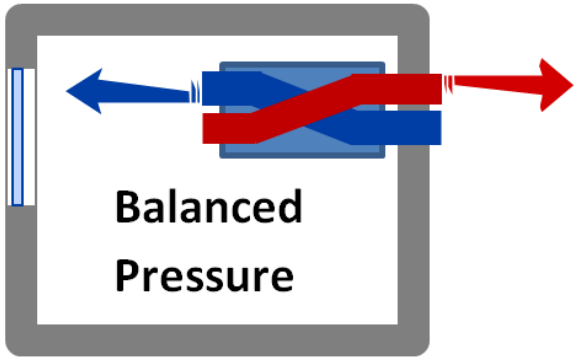
Not recommended for the Montana climate.



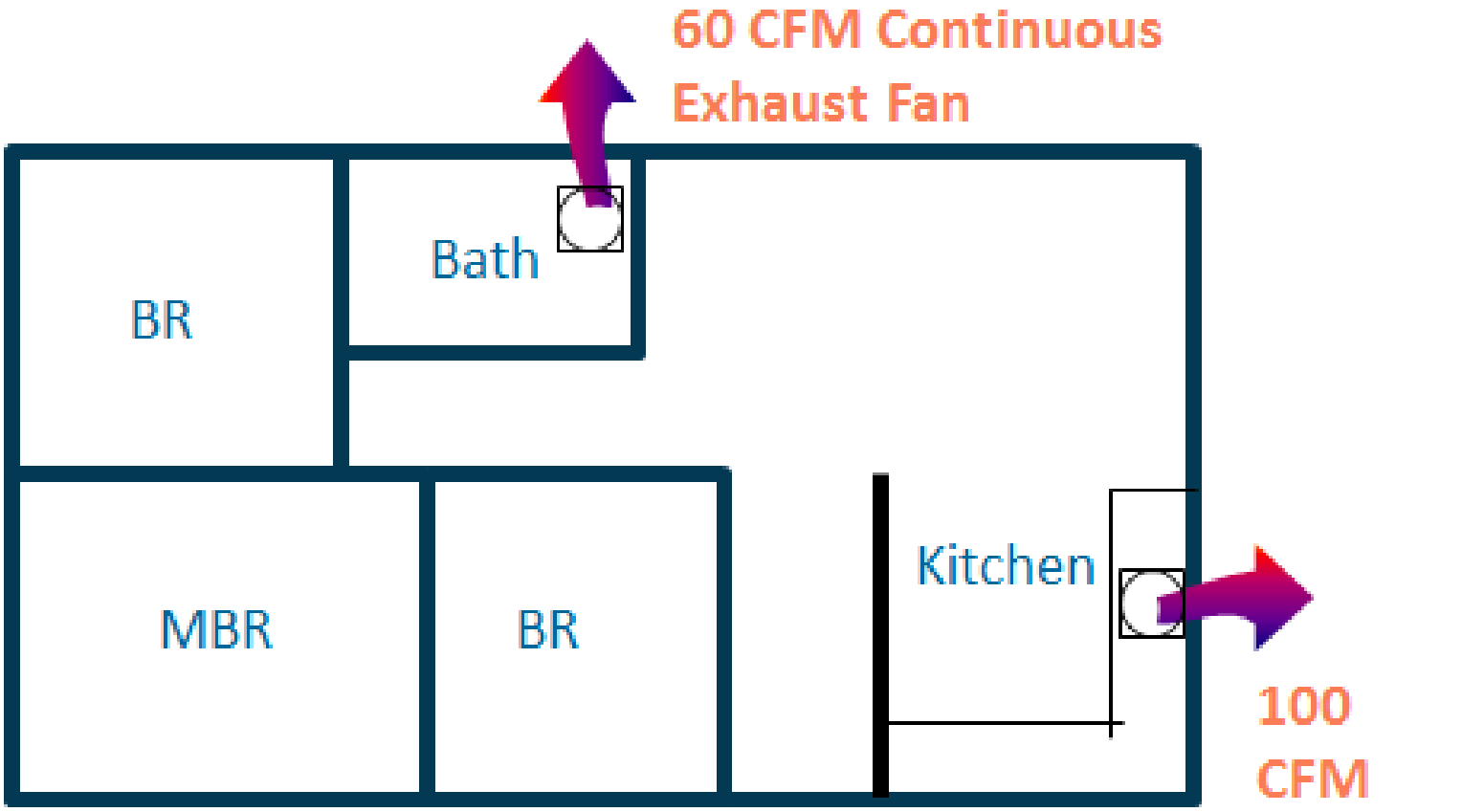
Balanced Mechanical Ventilation without Heat Recovery



Balanced Mechanical Ventilation with Heat Recovery

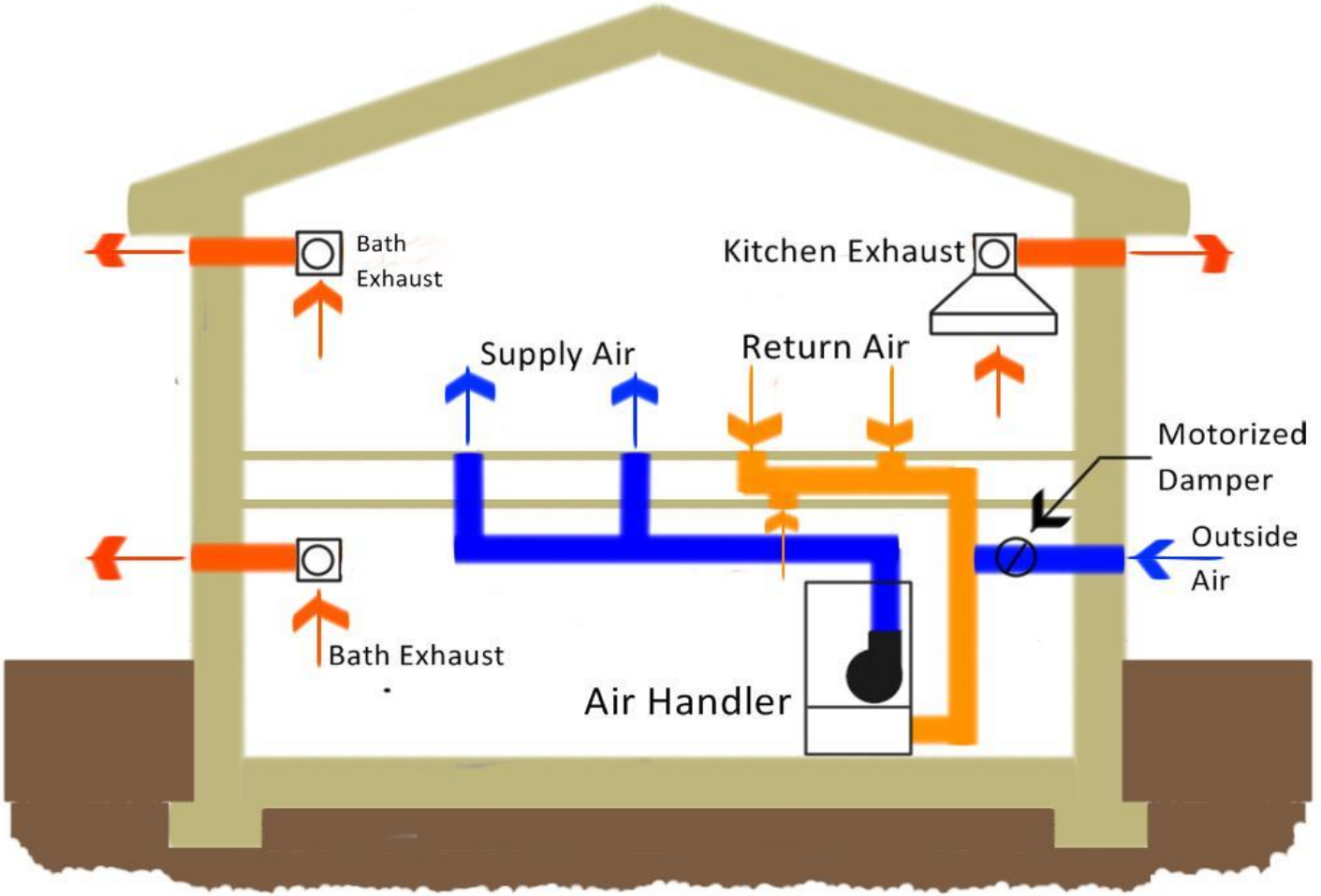


Whole House Ventilation Example



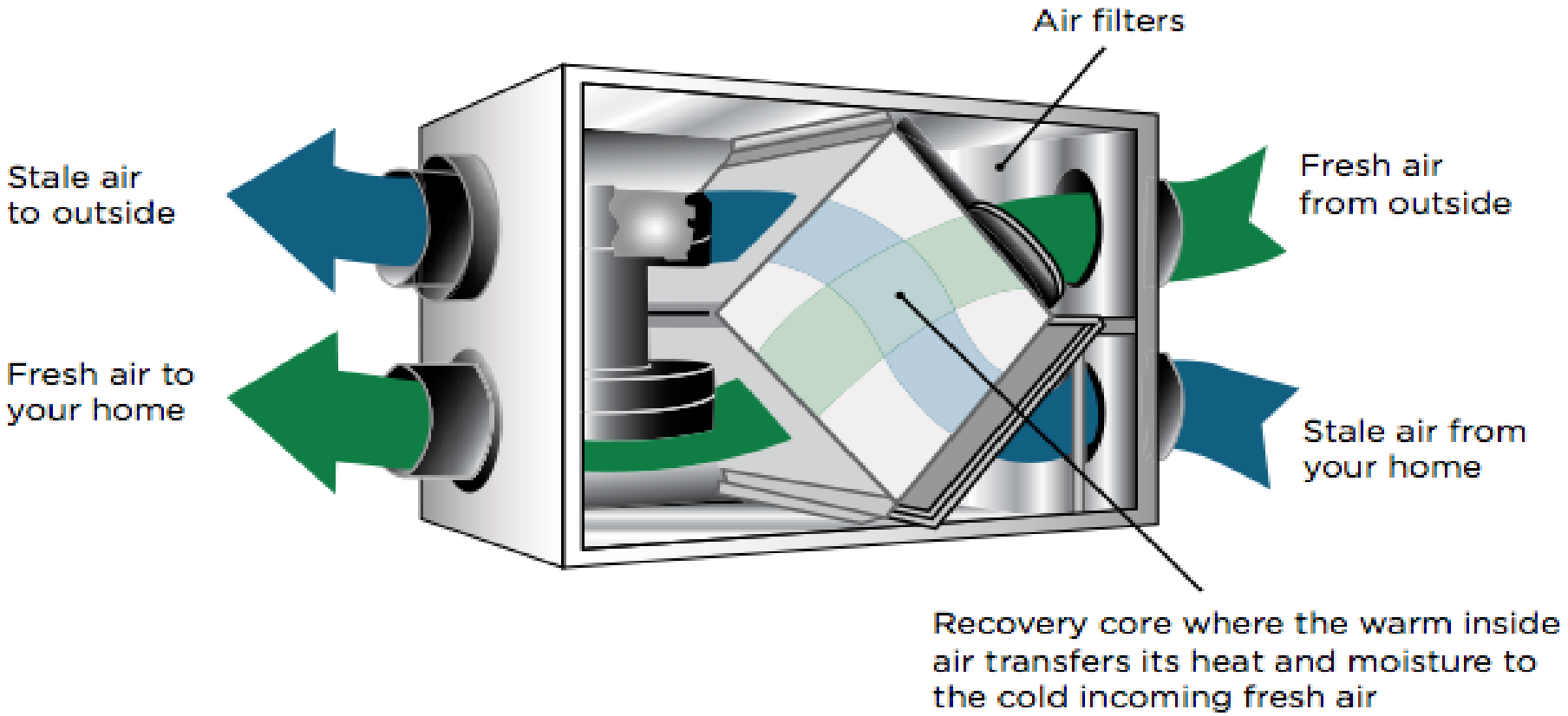
3BR, 2000 SF House = 60 CFM

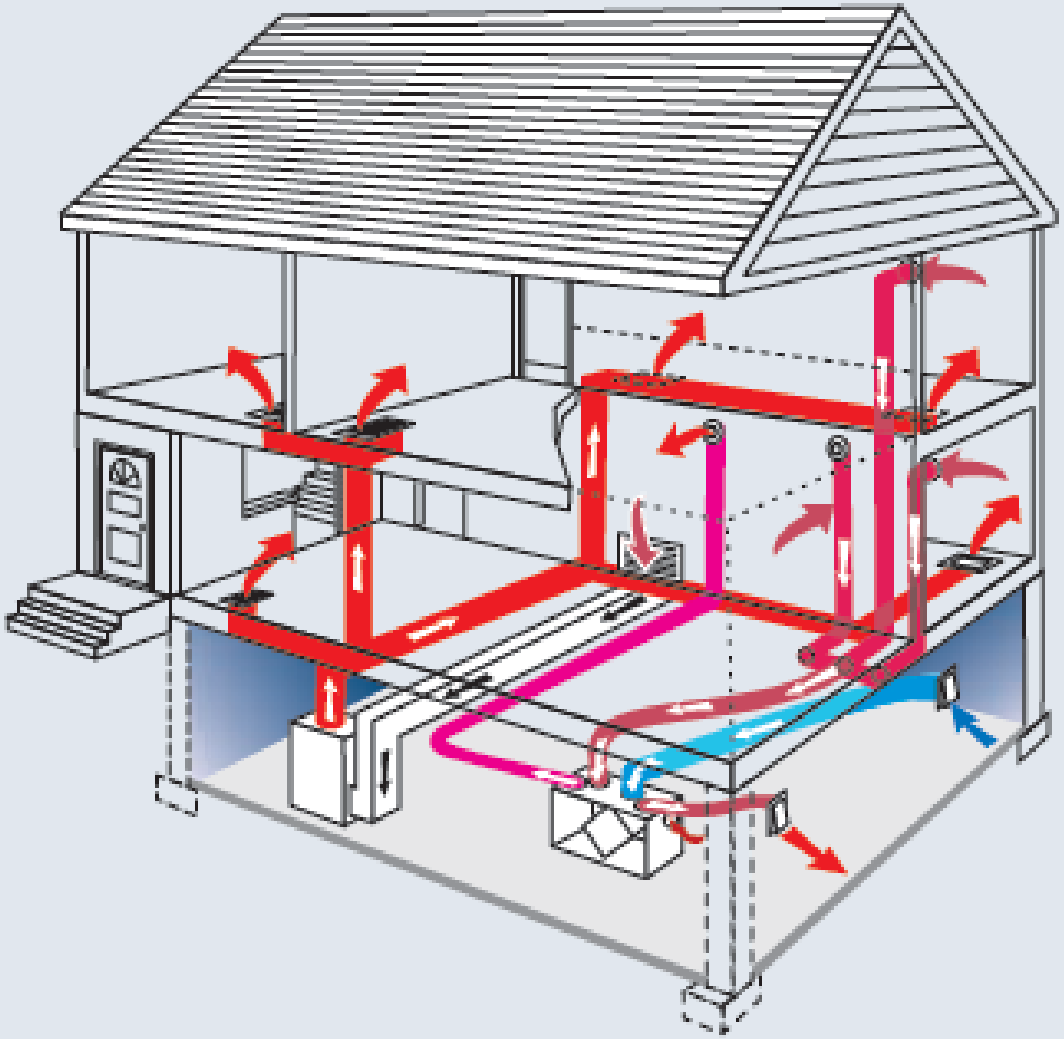
Central Balanced Exhaust without Heat Recovery



Balanced ventilation system with fresh air intake integrated with air handler and exhaust fan(s).

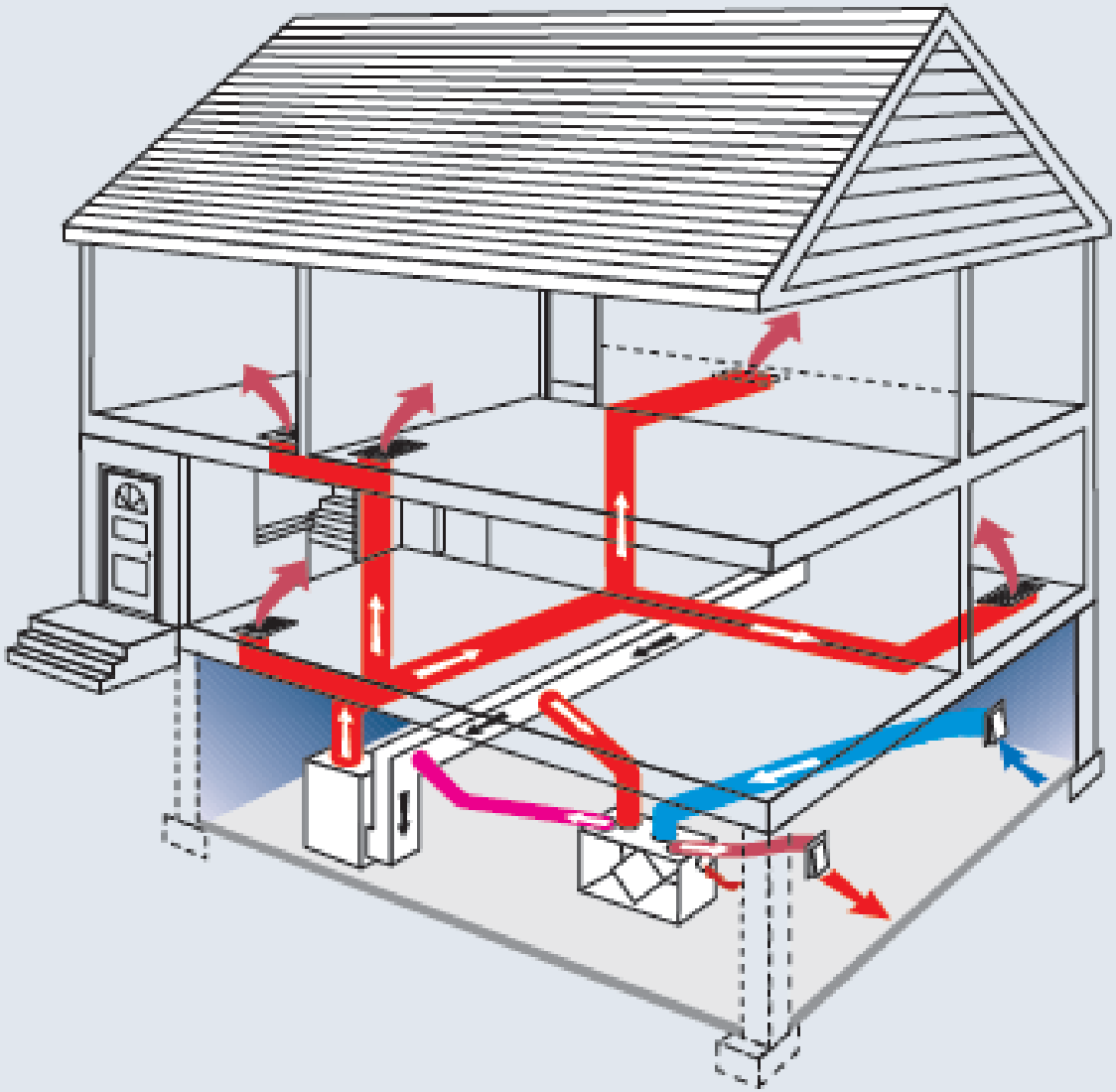
Heat Recovery Ventilator (HRV)





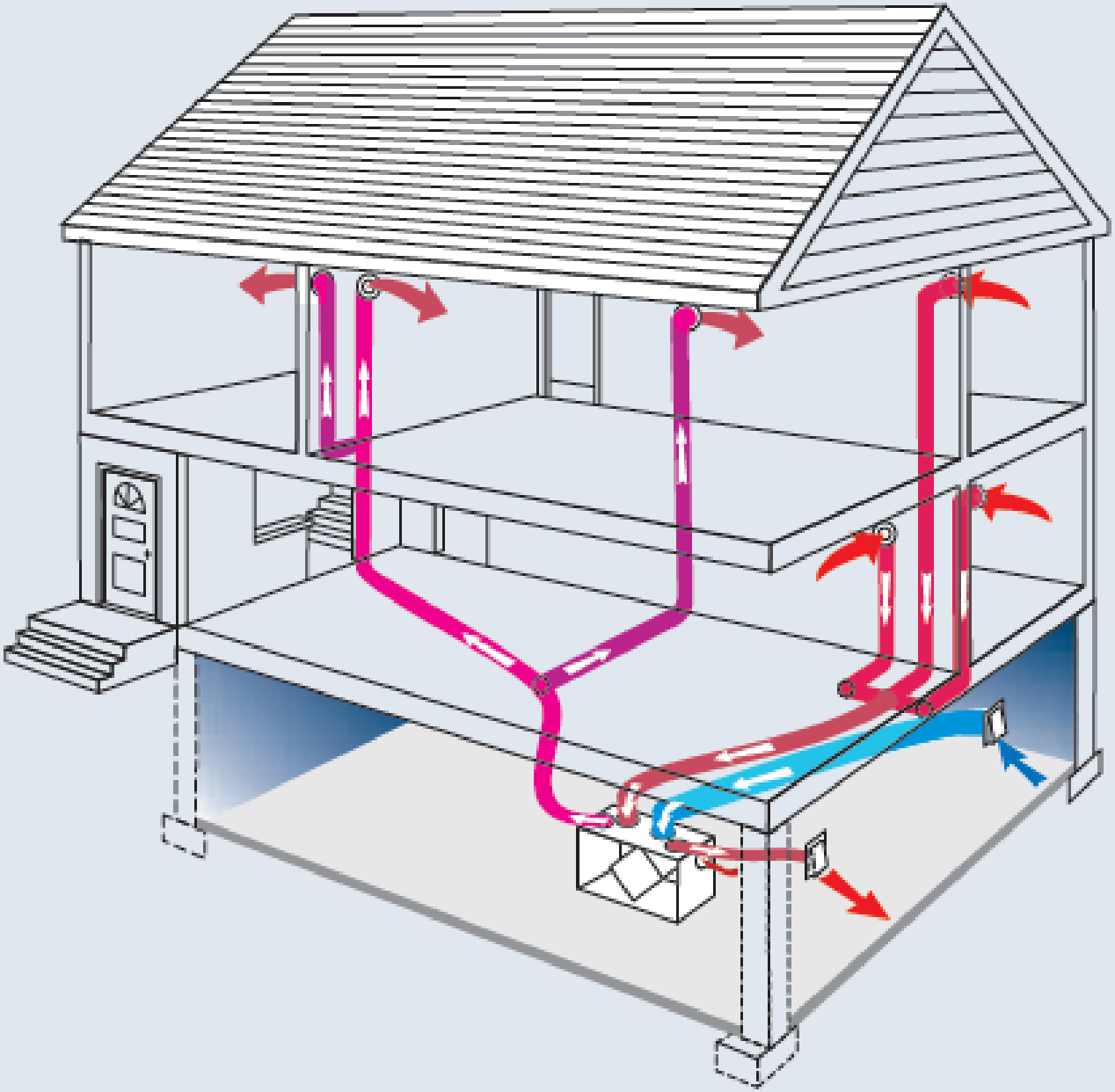
Dedicated Exhaust Points with Distribution of Fresh Supply Air through the Central H/AC System

Source: Aldes



Exhaust from H/AC Return and Distribution of Fresh Air through H/AC System

Source: Aldes



Source: Aldes

Fully Ducted System

Source: Venmar

Humidity Control
(P/N 611224)

Multifunction Control
(P/N 611227)

20/40/60 Timer
(P/N 611228)

Speed Control
(P/N 611229)

Source: Aldes

Why Are Air Pressures in a House Important?

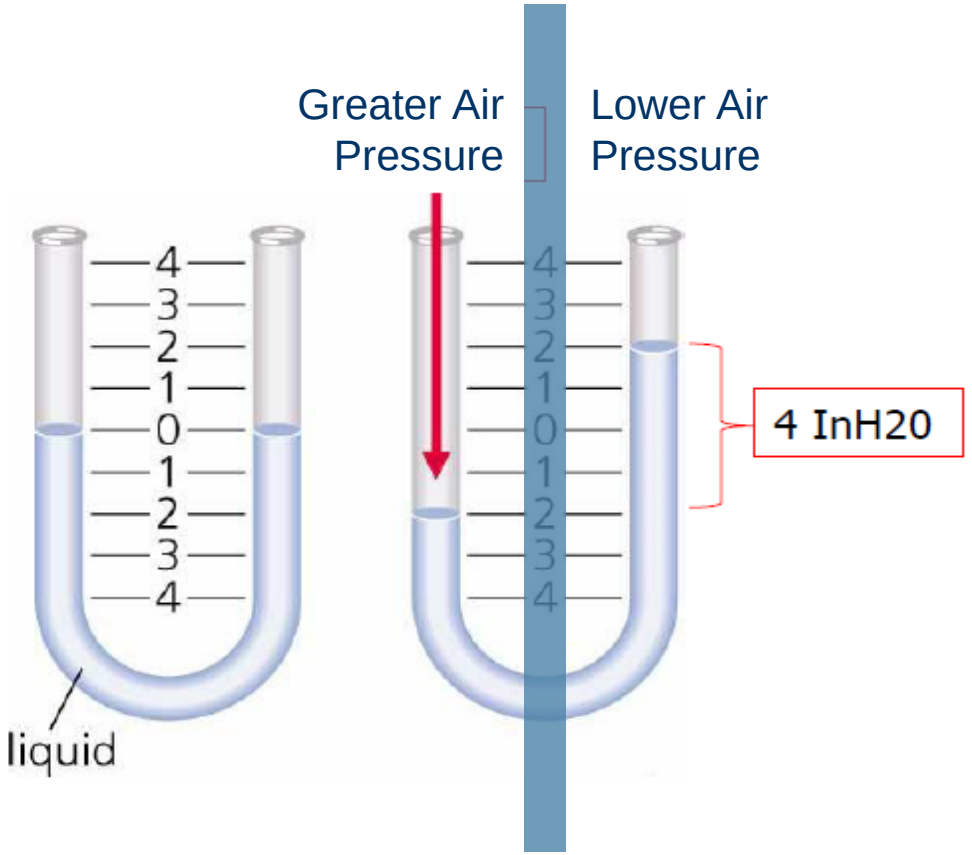
A Simple Manometer

What a manometer is:

- A pressure gauge

What a manometer does:

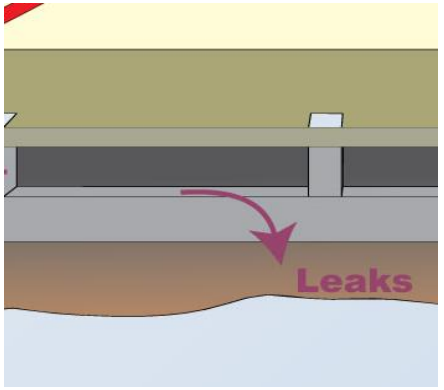
- Measures the pressure *difference* between two areas.

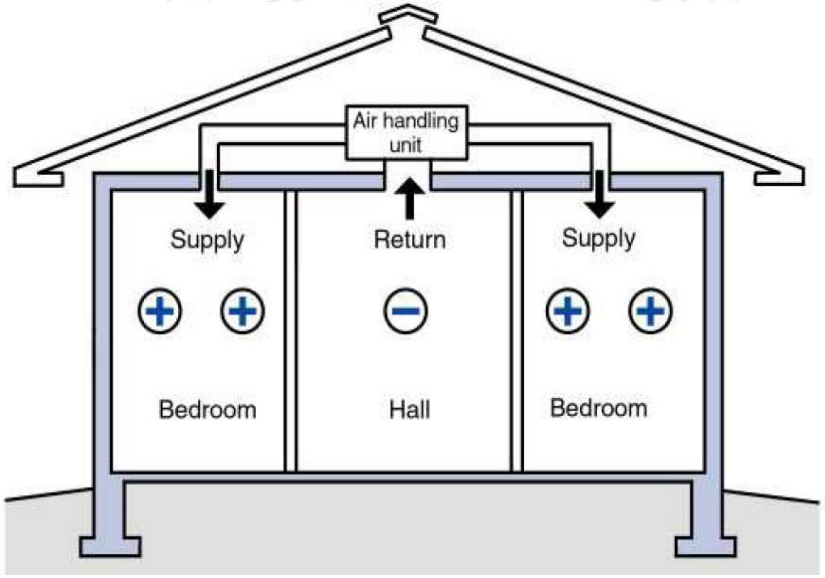


The original manometer

Pressure Change Driving Forces

- Wind
- Stack (the Chimney effect)
- Exhaust Fans
- Duct leakage
- Unbalanced forced air systems (interior door closure)

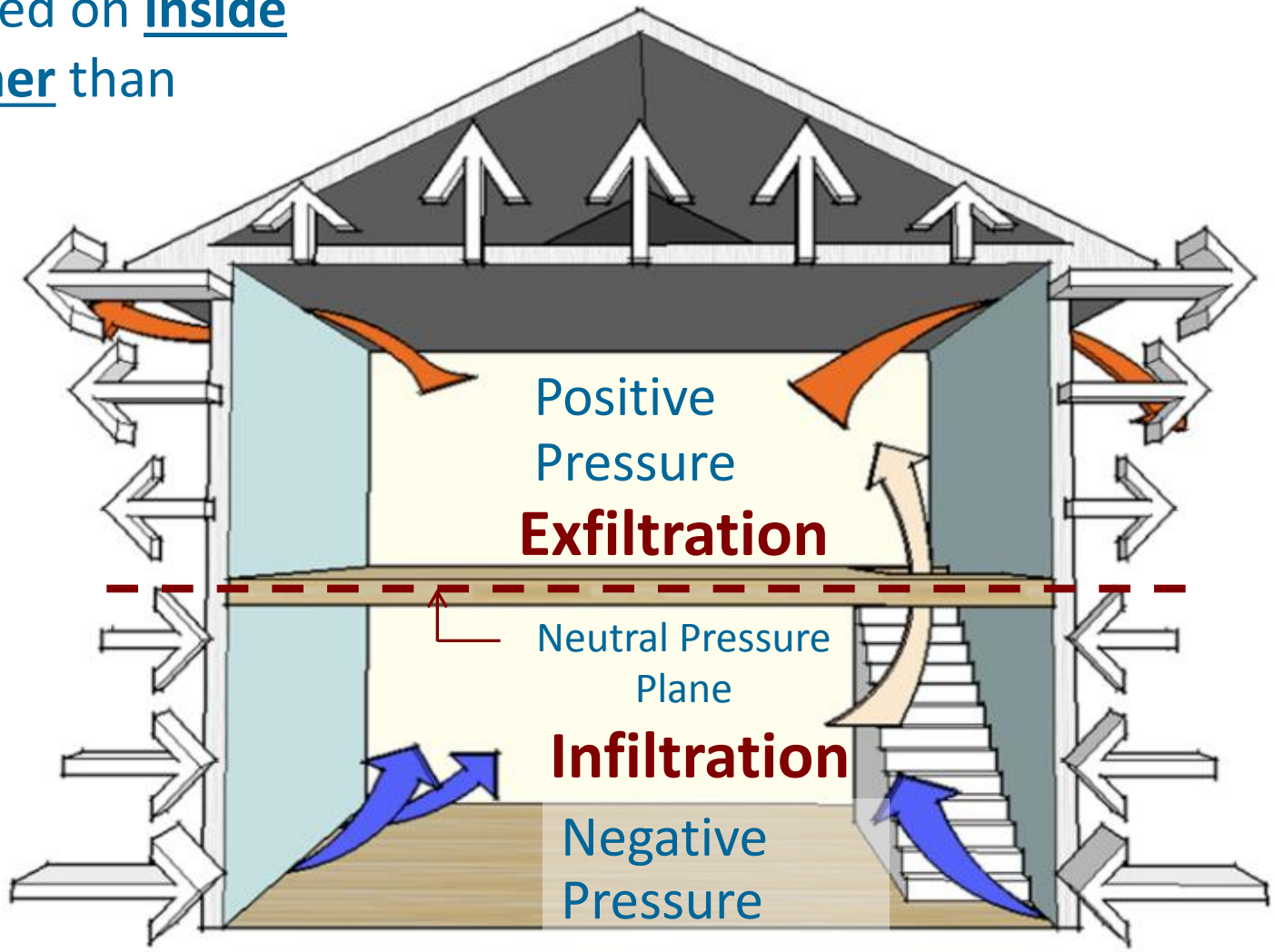




Stack Effect

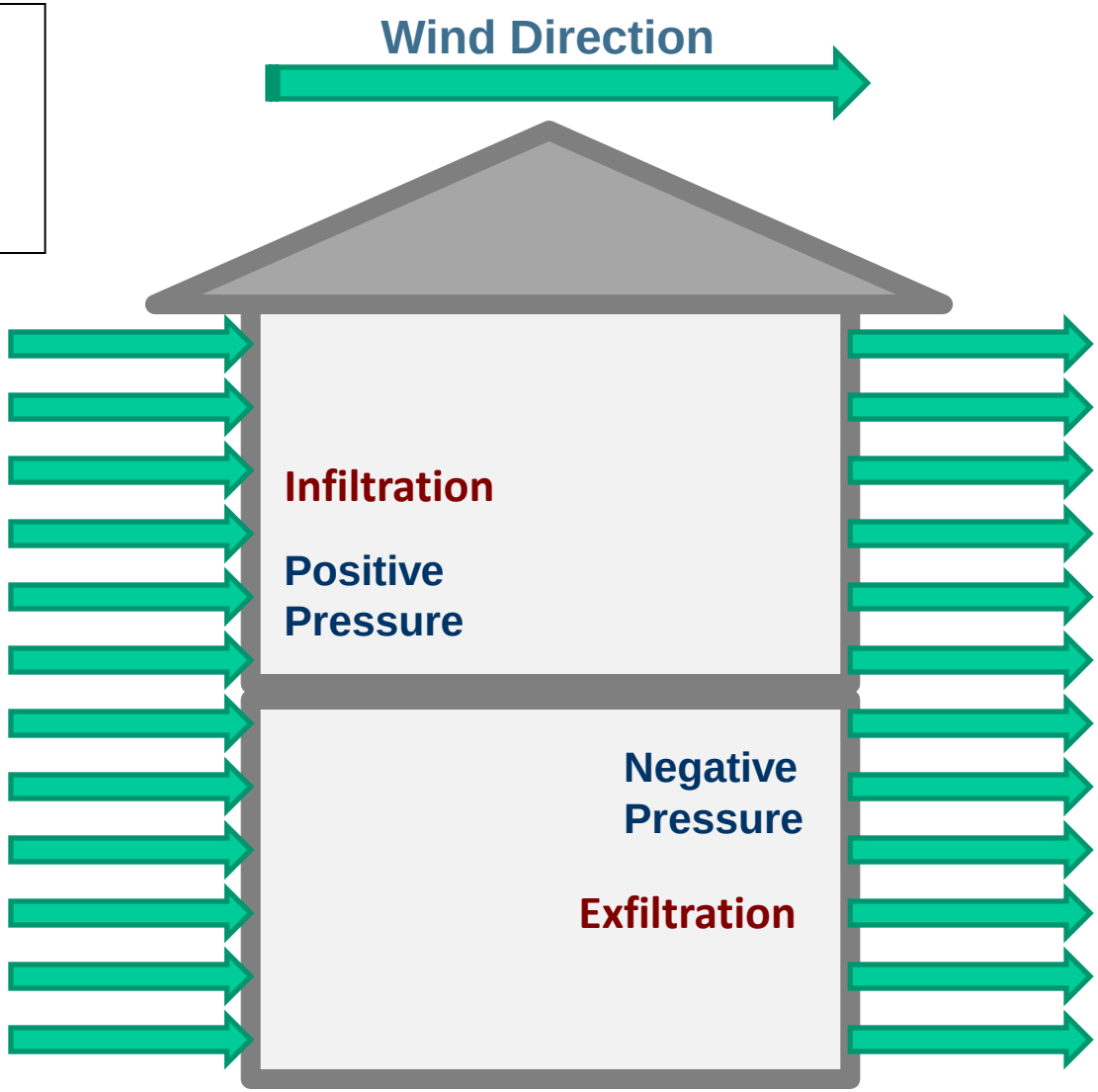
Diagram is based on **inside air being warmer** than outside air

When **outside air is warmer** than inside air, this process is reversed.

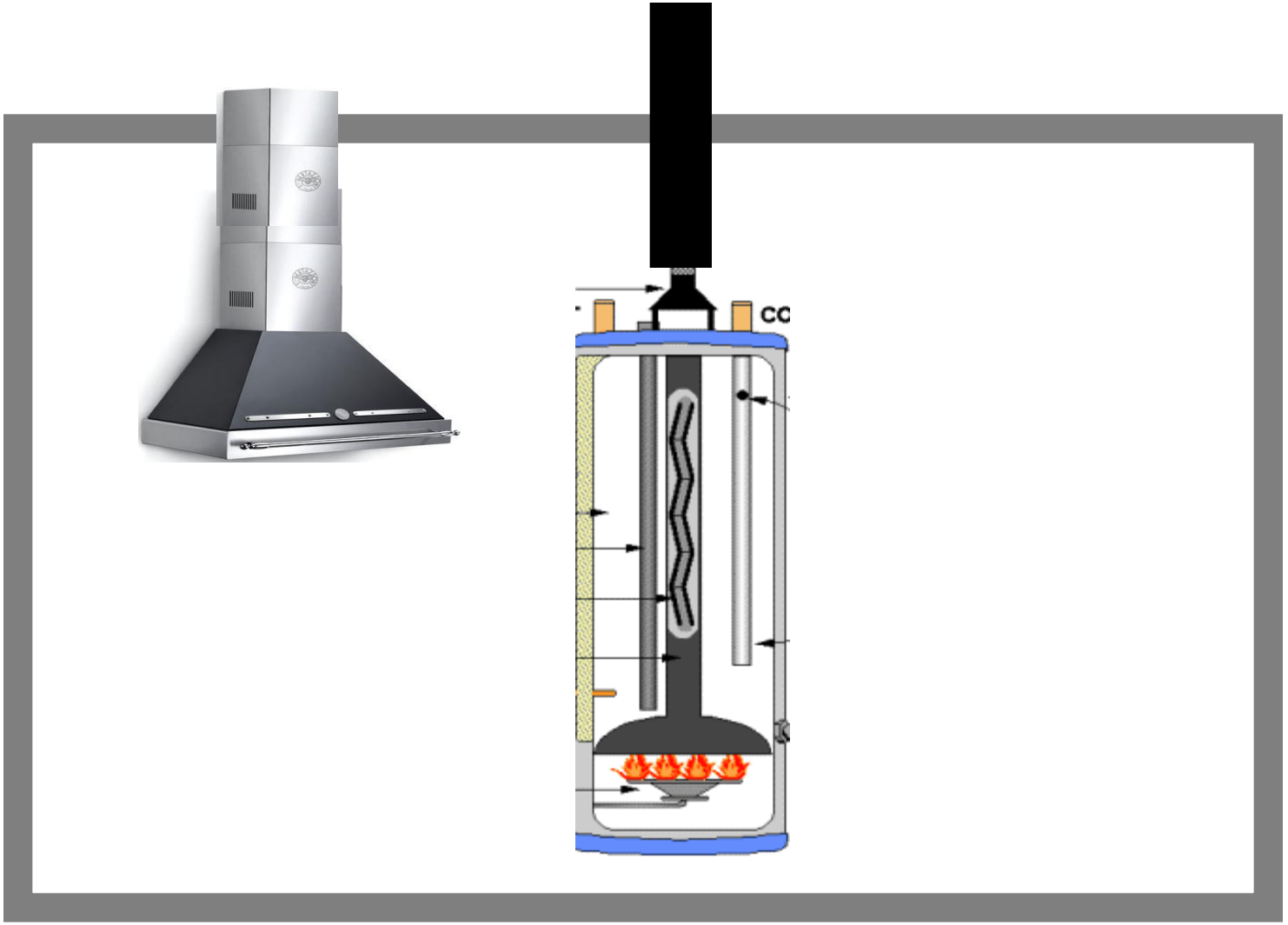


Wind Driven Pressures

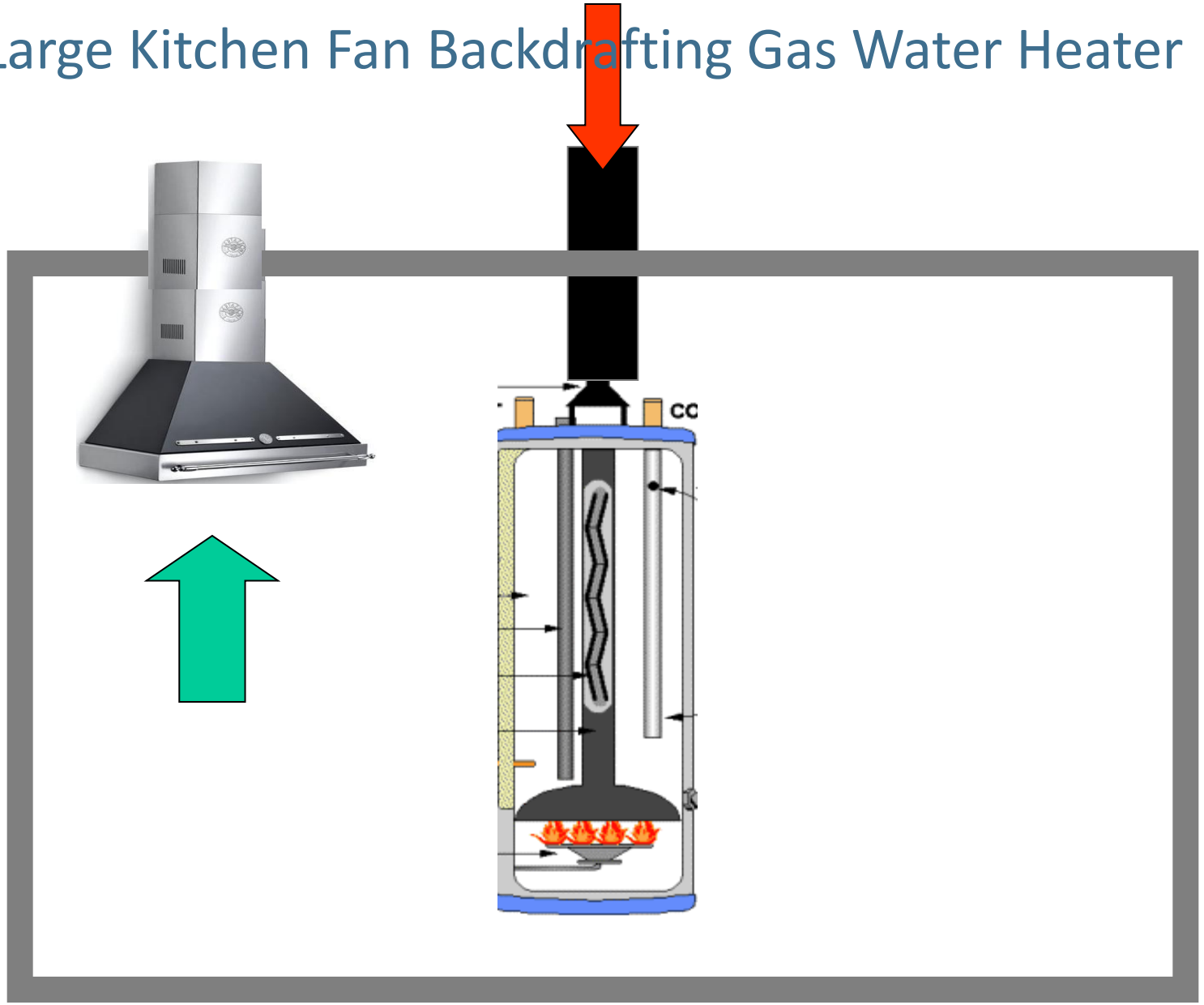
Wind creates positive and negative pressures within the house.



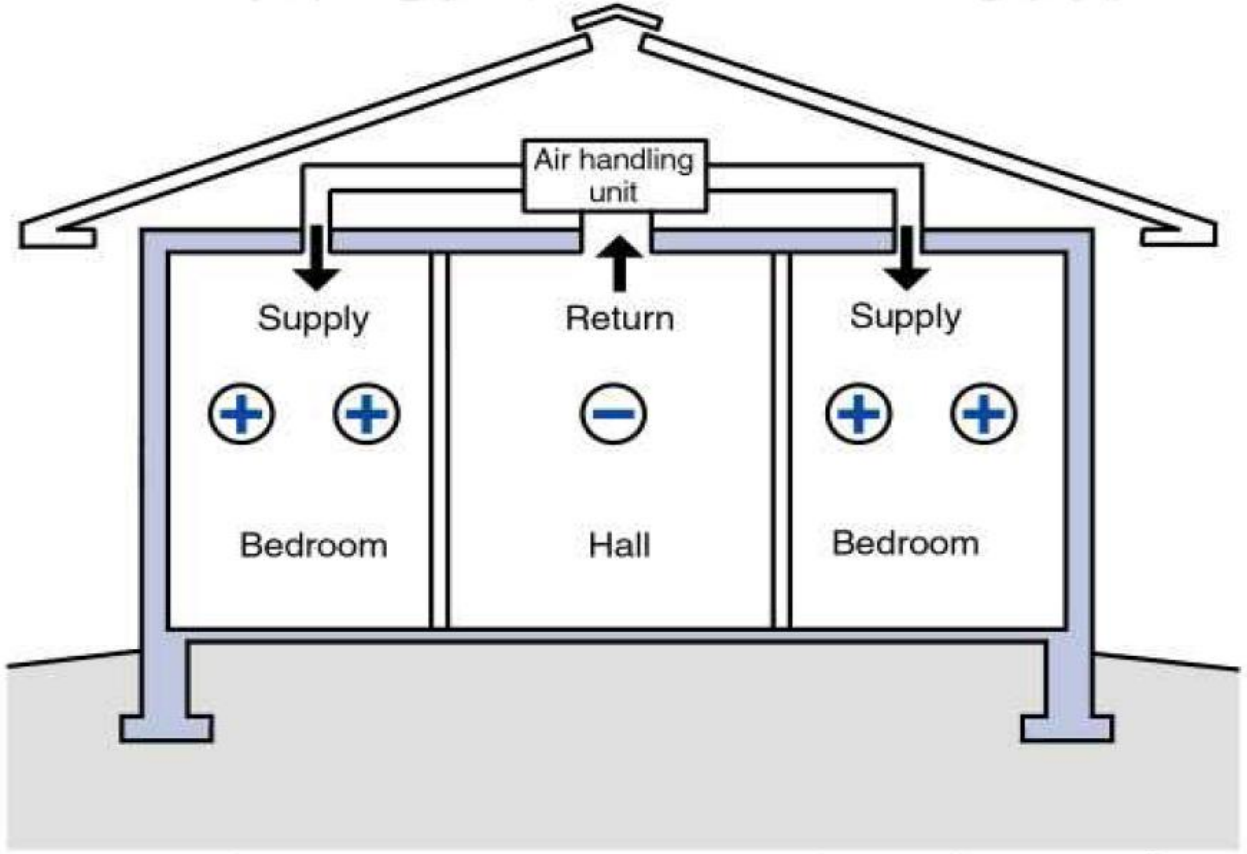
Correct Venting, Gas water Heater Venting Successfully



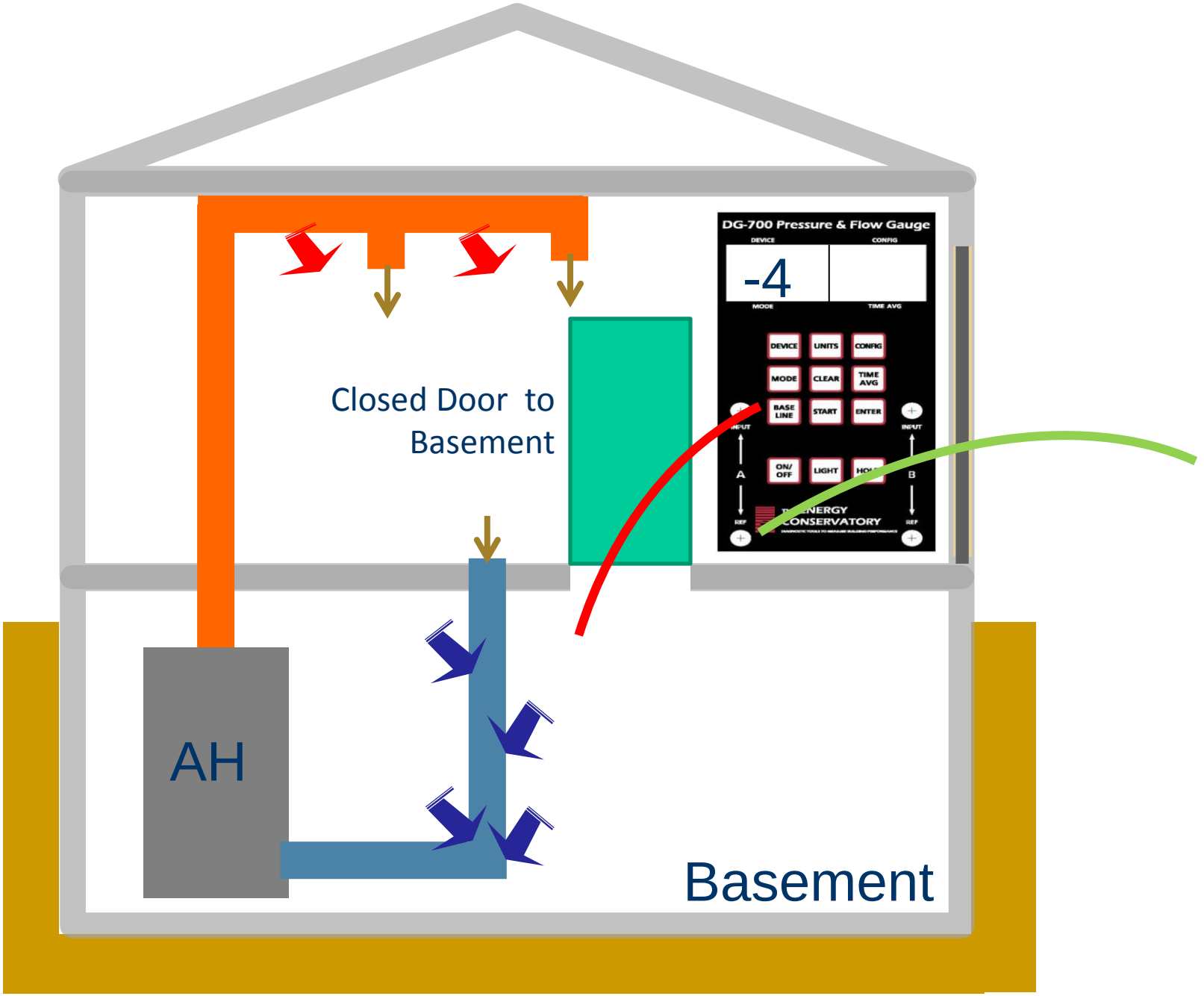
Large Kitchen Fan Backdrafting Gas Water Heater



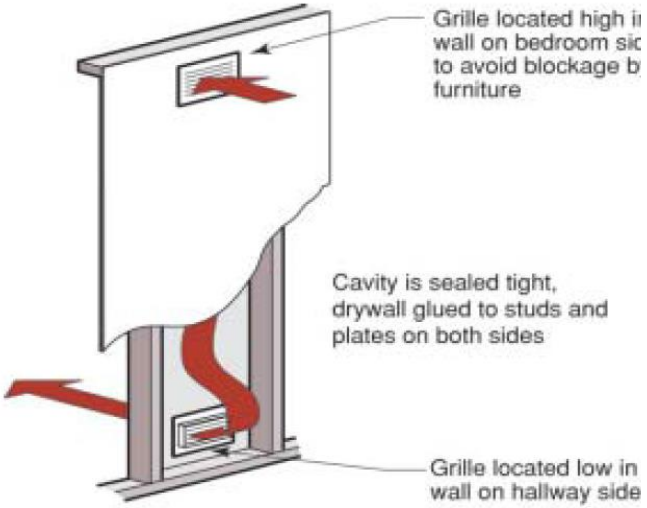
House Pressures

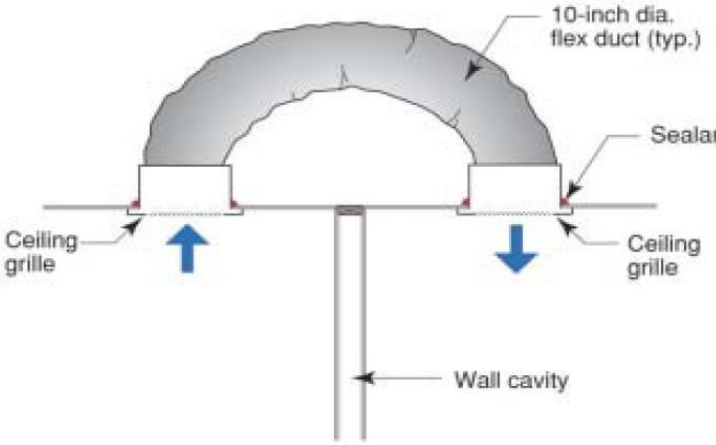


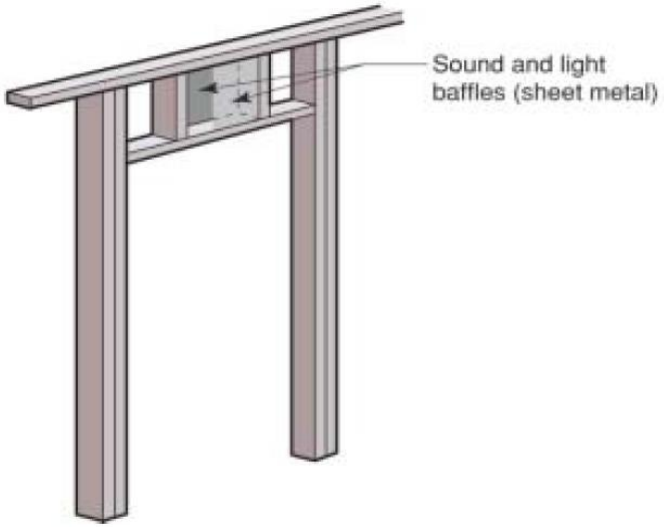
The ENERGY STAR program requires that the pressure between bedrooms and common area be tested to assure that the pressure difference in no more than 3 Pa.

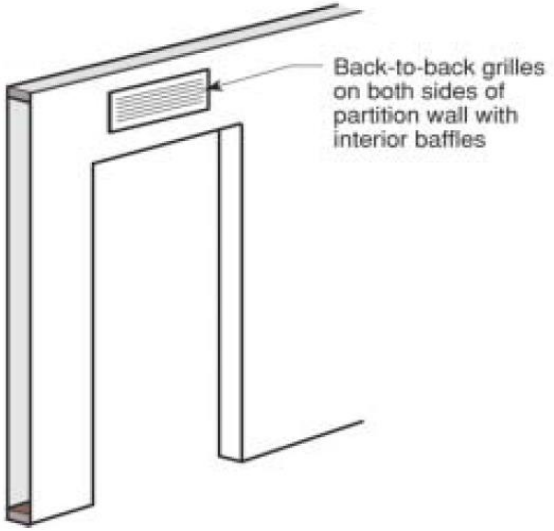

DG-700 Pressure & Flow Gauge
DEVICE
CONFIG
-4
MODE
TIME AVG
DEVICE
UNITS
CONFIG
MODE
CLEAR
TIME AVG
BASE LINE
START
ENTER
ON/ OFF
LIGHT
A
B
REF
Closed Door to Basement
AH
Basement

Examples of Jump Ducts and Transfer Grilles









Source: USDOE Building Technologies Program, Whole-House Energy Savings in Cold and Very Cold Climates

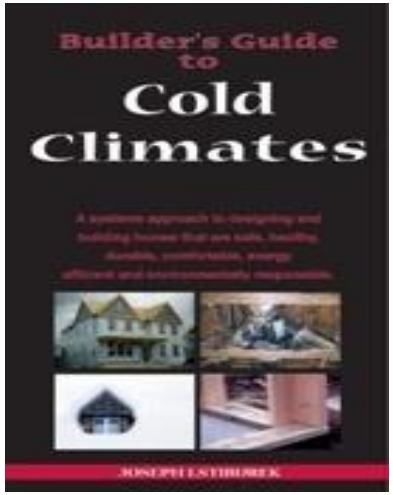
Energy Codes – Recommended Sites

www.energycodes.gov

//deq.mt.gov/Energy/EnergizeMT/energycode

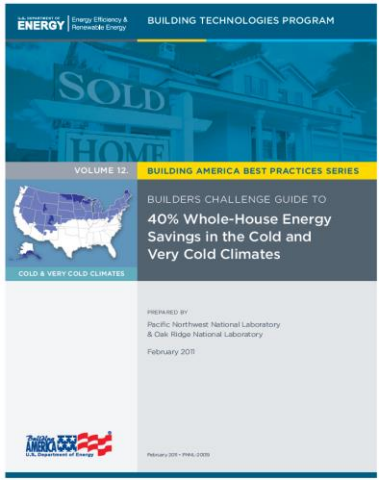
DEQ
Montana Department
of Environmental Quality

How Buildings Work – Great References



Builder's Guide to Cold Climates

By Joe Lstiburek, Published by EEBA



Building America Best Practices Series Volume 12: 40% Whole-House Energy Savings in the Cold and Very Cold Climates

How Buildings Work – Great Web Sites

https://buildingscience.com

www.greenbuildingadvisor

Presentations Online

NCAT NATIONAL CENTER FOR APPROPRIATE TECHNOLOGY

www.ncat.org

➔ Energy

➔ Energy Code Training Presentations